

MARCH 1951



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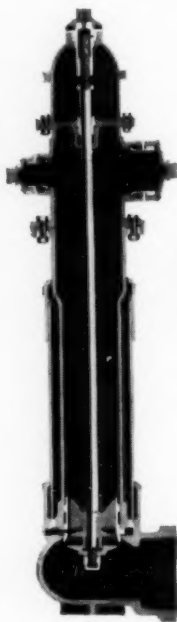
Journal

AMERICAN
WATER WORKS
ASSOCIATION

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Association Activities	Committee Reports

*As of March 31, 1951, A.W.W.A.'s new address will be:
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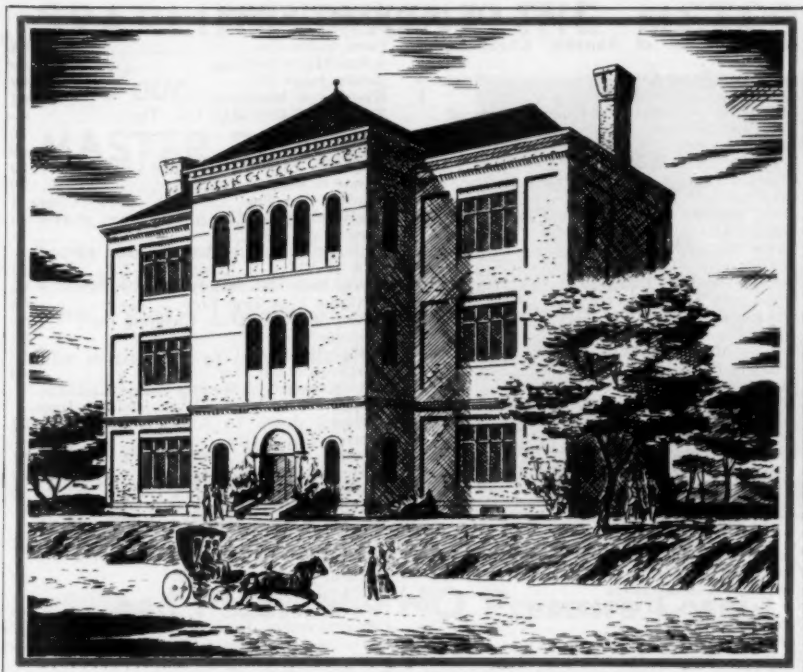
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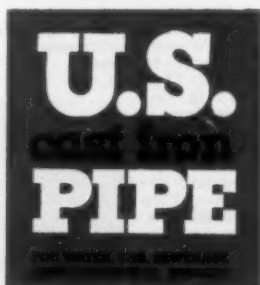
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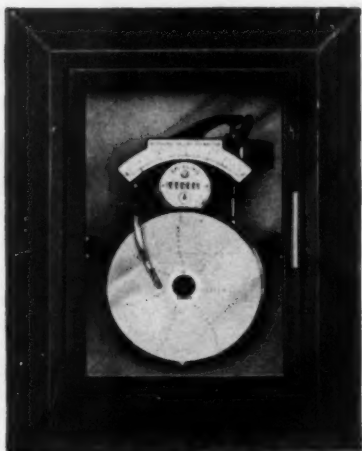
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Sparling Meters are noted for their conservation of line pressure. Even the Compound Meters—shown below, with flow ranges as high as 1 to 125—show less pressure drop than ordinary meters. That is part of Sparling economy.



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1932 First Avenue.....SEATTLE 1
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COMING MEETINGS

- March** 15—New England Section at Hotel Statler, Boston, Mass. Secretary: G. G. Bogren, Weston & Sampson, 14 Beacon St., Boston 8.
- 28-30—Illinois Section at La Salle Hotel, Chicago. Secretary: J. L. Hart, Asst. Western Sales Mgr., U.S. Pipe & Foundry Co., 122 S. Michigan Ave., Chicago 3.
- 29-31—Arizona Section at El Tovar Hotel, Grand Canyon. Secretary: Mrs. Helen Rotthaus, San. Eng. Div., State Dept. of Health, Phoenix.
- April** 5-6—New York Section at Hotel Ten Eyck, Albany. Secretary: R. K. Blanchard, Vice-Pres., Neptune Meter Co., 50 W. 50 St., New York 20.
- 11-13—Kansas Section at Lamer Hotel, Hays. Secretary: H. W. Badley, Neptune Meter Co., 640 Highland St., Salina.
- 19-20—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary: E. Bruce Meier, Dept. of Civ. Eng., University of Nebraska, Lincoln.
- 20-21—Montana Section at Placer Hotel, Helena. Secretary: A. W. Clarkson, Asst. Director, Div. of San. Eng., State Board of Health, 1036 Eighth Ave., Helena.

A.W.W.A. 1951 ANNUAL CONFERENCE

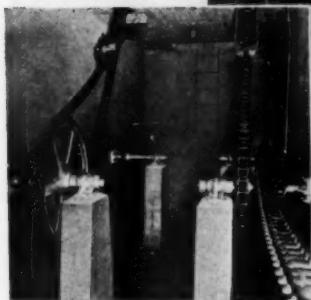
Miami, Fla., April 29—May 4

Reservation forms have been mailed to all members and all reservations will be cleared through the A.W.W.A. office. The hotels have agreed to accept no reservations for the 1951 Conference except as they are requested on the standard form provided by the A.W.W.A.

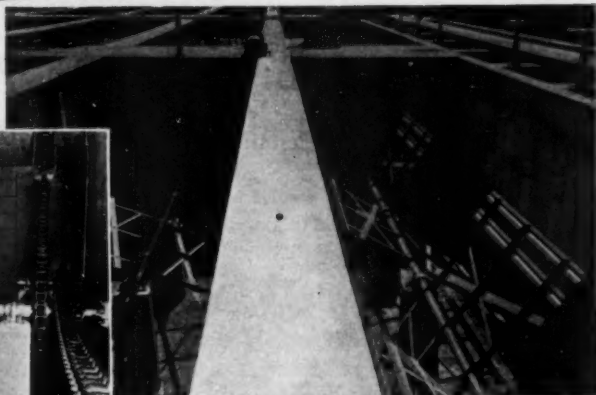
71st Annual Conference

- Apr. 29—May 4**—Southeastern Section will hold a business meeting during the Miami Conference.
- May** 17-19—Pacific Northwest Section at Vancouver Hotel, Vancouver, B.C. Secretary: O. P. Newman, Secy., Boise Water Corp., Boise, Idaho.
- 21-23—Canadian Section at Royal Alexandra Hotel, Winnipeg, Man. Secretary: A. E. Berry, Ontario Dept. of Health, Parliament Bldgs., Toronto 2, Ont.
- June** 29—New Jersey Section Summer Meeting (inspection trip and luncheon), Trenton, N.J. Secretary, C. B. Tygert, Box 178, Newark 1, N.J.

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without trouble!



Closeup of Dorrcoc Flocculator drive mechanism showing completely enclosed dry well



A typical Dorrcoc Flocculator installation, showing two rows of paddles with basin in foreground empty

That's the actual case history of a Dorrcoc Flocculator installation at a large Eastern water treatment plant. The water works superintendent reports absolutely no trouble with bearings, paddles, or drive mechanism since this unit was first installed in 1939 at a design capacity of 10 M.G.D. This is typical of the operating dependability you get with Dorrcoc Flocculators. The dry well feature means that the entire drive mechanism is never exposed to water and is readily accessible at all times.

If you have existing plain basins,

chances are they can be converted easily—and at a substantial saving in cost. New plant or modernization, Dorrcoc Flocculators will improve your entire pre-treatment operation. A close check on one installation after only three months of operations showed:

- Filter runs lengthened 40%.
- Wash water demands reduced 30%.
- Alum costs cut 30%.

Why not write for further information concerning the savings and increased efficiency that Dorrcoc Flocculators can achieve in your plant?

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An important optional design feature of the Dorrcoc Flocculator is the Automatic Lubricator for submerged bearings. Actuated by the shaft rotation, it contains over a year's supply of grease and insures trouble-free bearing operation at all times.

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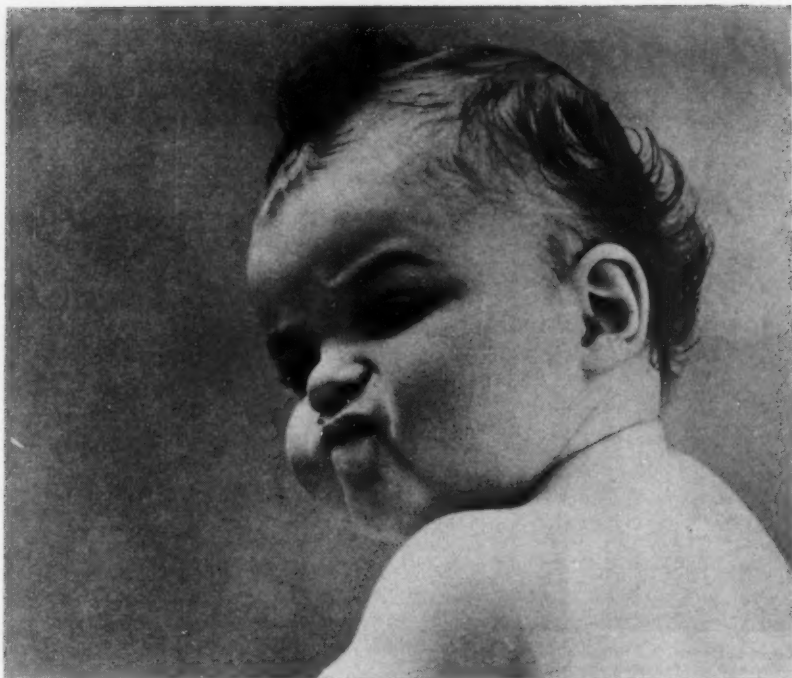
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Aqua Nuchar Activated Carbon can be used in two ways to eliminate troublesome algae which cause taste and odors in water supplies.



First, is the "blackout" method in which a slurry of Aqua Nuchar is used to exclude sunlight to eliminate algae growth. The second method is to physically remove algae by adsorption with Aqua Nuchar Activated Carbon.

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Journal

AMERICAN WATER WORKS ASSOCIATION

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March 1951

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
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Fluoridation News

1945  1950

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NEW YORK, N. Y.

W & T ENGINEERS
NEW YORK, N. Y.

Fluoridation has come a long way since that day in 1945 when W&T Engineers, in conjunction with health authorities, made the now so well known fluoridation installation at Newburgh, N. Y. At that time, fluoridation was in the experimental stage—was looked upon as a possible, though still to be proven, method of reducing the incidence of dental caries.

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Newburgh, N. Y. 1945

The Role of Sodium Silicate in Inhibiting Corrosion by Film Formation on Water Piping

By Leo Lehrman and Henry L. Shuldener

A contribution to the Journal by Leo Lehrman, Associate Professor of Chemistry of The College of the City of New York, New York, N.Y., and Henry L. Shuldener, President and Technical Director, Water Service Laboratories, Inc., New York, N.Y.

ONE of the most effective methods employed for the control of corrosion in domestic water piping is the continuous addition of small amounts of sodium silicate (containing approximately 8-12 ppm. SiO_2) to the water (1). When it is used, a self-healing, thin, protective film forms on the inside surface of the pipe, effectively stopping corrosion.

The film has been shown to contain silica or a silicate (2, p. 367), and not to build on itself although sodium silicate had been added continuously to the water (New York City supply) for a period of twenty years.* When wet, it is gelatinous and difficult to see; when dry, it becomes visible as a thin, light brown coating, due to the presence of iron oxides.

*The latter evidence is taken from the Corrosion Research Exhibit maintained by Water Service Laboratories, Inc., New York, N.Y.

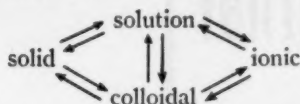
Previous Studies

The literature on the nature of sodium silicates in solution is almost completely confined to discussions of concentrated solutions, as in the work of Kohlrausch, Bogue, Stericker, Cann, Harman, Main, Ganguly and Debye.†

In water treated with small amounts of sodium silicate, it has been hypothesized that the film could be formed in two ways: [1] by a chemical reaction between the metal ions of the pipe and the silicate ions (3); and [2] by the neutralization of negatively charged silicate ions or silica micelles by positively charged metal ions or colloidal oxides (2, p. 367). The necessary components for either mechanism are present in very dilute sodium silicate

†To save space, the list of references has been abbreviated. The authors will be glad to furnish interested readers with specific references.

solutions, if the following equilibria are postulated (4):



Several investigators—Thomas, Texter, Stericker and Evans—are of the opinion that a chemical reaction takes place between metal ions, or corrosion products of metals, and negatively charged silicate ions or silica micelles. There is no convincing experimental evidence, however, that this is the manner in which the protective film is formed. Others—Vail, Hazel, Schwartz, Merrill and Leaf—indicate that it is a neutralization of oppositely charged particles which results in coagulation and adsorption.

Thus it would seem that the formation of the film is a colloidal phenomenon, involving either colloidal or ionic silica, even though in very low concentrations of sodium silicate, the amount of colloidal silica is small compared with the amount of ionic silica (5). The fact that there is an equilibrium between the two kinds of silica, however,

allows for the one in low concentration to be continually replenished.

When a silica film is formed in a water pipe, it is gelatinous. It is therefore of interest to note that the conditions affecting the formation of silica gel from sodium silicate solutions have been rather extensively studied by Hurd (6), who described the gel as a solid of fibrous structure containing liquid in the pores.

On the basis of the work reviewed, it would appear, from a theoretical point of view, that the silica film forms from the mutual neutralization of oppositely charged particles which results in the formation of a gel. The experimental evidence to confirm this mechanism, however, is meager. The object of this work was to investigate the composition of extremely dilute sodium silicate solutions and their action with metals and metal corrosion products. It was hoped that the results would contribute to an explanation of the mechanism of film formation in water pipes, when very small amounts of sodium silicate (approximately 8 ppm. SiO_2) are added to prevent corrosion.

Experimental

Experiment 1

Change in Properties of Sodium Silicate With Dilution and Time

It has already been stated that earlier investigators had noticed that changes take place when sodium silicate solutions are diluted. The solutions they used, however, were rather concentrated and the specific nature of the changes was not studied. The first of a series of experiments was carried out therefore to determine how the amount of ionic and colloidal silica, and the pH value, vary when a strong sodium silicate solution of 1:3.22 (Na_2O :

SiO_2), containing 40 per cent solids (approximately 400,000 ppm. SiO_2^*), pure sodium metasilicate, $\text{Na}_2\text{SiO}_3 \cdot 9\text{H}_2\text{O}$ (1:1 Na_2O : SiO_2), and commercial brand anhydrous, Na_2SiO_3 , are made into dilute solutions. Dilutions of the same concentration were made in two ways: one, by adding the sodium silicate to the water and the other, by reversing this procedure. The criteria used were pH, amount of SiO_2 determined colorimetrically and dark field

*A 1:3.22 Na_2O : SiO_2 solution will be called HS (high silica). Commercial solid anhydrous Na_2SiO_3 , 1:1 Na_2O : SiO_2 , will be called LS (low silica).

microscopic examination for colloidal particles.

The solutions were made with distilled water and stored in glass stoppered Pyrex bottles. The pH was determined with a Cambridge pH meter, and the SiO_2 , colorimetrically by the Kahler method, using a Klett-Sumerson photoelectric colorimeter on the solutions, directly (ionic silica

gave a higher but practically constant value during the seven-day period. The direct method (ionic silica) gave an initial lower value which decreased rapidly the first day, but more gradually from then on. There was a distinct difference, however, in the initial amount of silica determined directly, between the solution made by adding the sodium silicate to water (1,220 ppm. SiO_2),

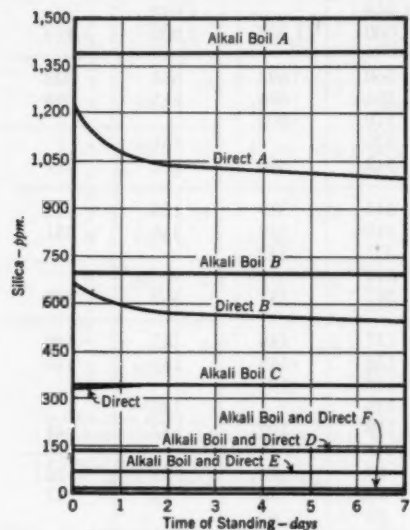


Fig. 1. Effect of Time on Silica Concentration

Change in amount of silica, as determined colorimetrically (directly and after an alkali boil), after varying periods. The solutions were made by adding concentrated sodium silicate solution (HS) to water.

only), and after boiling with sodium hydroxide in stainless steel beakers (ionic silica + colloidal silica = total silica) (Stericker). The results are given in Tables 1 and 2 and Fig. 1 and 2.

Determination of the amount of silica showed that, at high concentrations (1,400 and 700 ppm.), the alkali boiling method (ionic + colloidal silica)

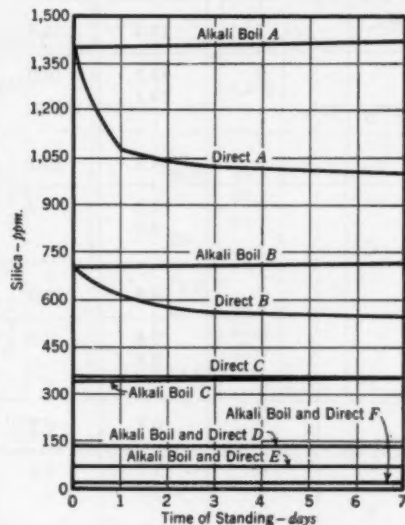


Fig. 2. Effect of Time on Silica Concentration

Change in amount of silica after varying periods. The conditions are the same as for Fig. 1, except that the solutions were made by adding water to sodium silicate solution, instead of the reverse.

and the one made by reversing the procedure (1,349 ppm. SiO_2). The decrease in the amount of silica of the former, on standing, was more gradual than the latter, but after seven days, both were the same (1,000 ppm. SiO_2). In the 700 ppm. SiO_2 solutions, the same trend was observed, while more dilute solutions showed practically no difference.

TABLE 1
Value of pH and SiO₂ Content of Dilute Sodium Silicate Solutions

Soln.	Days	pH		SiO ₂ Content—ppm.			
				S*		W†	
		S*	W†	Direct	Alkali Boil	Direct	Alkali Boil
A	0	10.4	10.3	1,220	1,390	1,390	1,396
	1	10.5		1,070	1,390	1,075	1,424
	2			1,045			
	3			1,040		1,019	
	7	10.4	10.5	1,000	1,400	1,000	1,413
B	0	10.1	10.0	660	695	698	698
	1	10.1		595	695	615	698
	2			570	695		
	3			570		561	
	7	10.1	10.2	547	690	552	717
C	0	10.0	9.9	342	349	356	344
	1	9.9		349	349	356	351
	2			351	349		
	3			349			
	7	9.8	10.0	347	351	359	356
D	0	9.8	9.8	137	140	142	140
	1	9.8		138	139	142	146
	2			140	137		
	3			139		146	
	7	9.7	9.7	139	140	142	141
E	0	9.7	9.6	69	71	71	70
	1	9.7		71	70	75	72
	2			70	69		
	3			70		73	
	7	9.5	9.6	70	70	71	72
F	0	8.9	7.9	13.7	14.1	14.2	14.2
	1	8.5		14.1	13.9	14.9	14.0
	2			14.1	13.8		
	3			13.9		14.6	
	7	7.1	7.0	14.1	14.0	14.2	14.3

* S—Solution made by adding concentrated sodium silicate solution (HS) to water.

† W—Solution made by adding water to concentrated sodium silicate solution (HS).

All but the most dilute solution were buffered, as the pH remained constant. The most dilute solution, which was unbuffered, had its pH lowered because carbon dioxide was absorbed.

The various solutions were examined with a dark-field cardioid condenser, at

900 magnifications, for colloidal particles. Before observation, all solutions were centrifuged at 3,000 rpm. for 5 minutes to remove any coarsely dispersed particles. The original sodium silicate showed no colloidal particles, probably because of too small a differ-

TABLE 2

Value of pH and SiO₂ Content of Dilute Solutions of Pure Sodium Metasilicate and Commercial Anhydrous Sodium Metasilicate

Soln.	Days	pH				SiO ₂ Content—ppm.							
						S				W			
		S*		W†		Direct		Alkali Boil‡		Direct		Alkali Boil‡	
		PS§	LS	PS§	LS	PS§	LS	PS§	LS	PS§	LS	PS§	LS
A	0	12.1	12.1	12.1	12.1	1,321	1,236		1,245	1,321	1,236		1,236
	1					1,340	1,245	1,330		1,340	1,245	1,330	
	3												
	7		12.2		12.2		1,245				1,245		
	8	12.2		12.1		1,396		1,357	1,252	1,368		1,349	1,245
E	0	10.8	10.8	10.8	10.8	66.5				66			
	1					70.3	62.7			68.4	62.7		
	3						61.3				61.3		
	7		10.1		10.6		62.5				61.5		
	8	10.8		10.8		72				70			
F	0	10.0	9.9	10.0	9.9	13.2				13.3			
	1					13.6	12.5			13.6	12.7		
	3						12.3				12.3		
	7		9.7		9.8		12.5				12.5		
	8	10.0		10.0		13.8				13.9			

* S—Solutions made by adding solid sodium silicate to water.

† W—Solutions made by adding water to solid sodium silicate.

‡ Due to the high pH, alkali boiling is unnecessary to determine total silica up to concentrations of 1,300 ppm.

§ PS—Cp. Na₂SiO₃·9H₂O.

|| LS—Commercial anhydrous Na₂SiO₃.

ence in refractive index between the colloidal particles and the bulk of the solution. Colloidal particles were observable in all the solutions, although the relative amounts varied. To obtain more information about the colloidal particles, solutions of the various chemicals, including distilled water, used in the colorimetric method of determining the amount of silica, were examined. Very few colloidal particles were seen. A sample of sodium silicate solution of about 70 ppm. SiO₂, which had shown a considerable number of colloidal particles, was devoid of them after the colorimetric analysis, even after standing a day.

Experiment 2

The Reaction Between Dilute Sodium Silicate Solutions and Ferrous, Ferric, Zinc and Cupric Hydroxides

It is well known that, when metals corrode in natural waters, hydroxides (hydrous oxides) form. If the liquid next to the metal becomes saturated with the hydroxide, the excess will precipitate out, often depositing on the metal. This creates the possibility of some reaction taking place between the solution of the hydroxide, or the wet solid hydroxide, and silica.

The purpose of the second experiment was to determine whether or not

any reaction takes place between saturated solutions of ferrous, ferric, zinc and cupric hydroxide and sodium silicate solutions of 10 and 300 ppm. SiO_2 , with solid hydroxides present or absent.

The ferrous hydroxide solution was prepared by adding pure iron powder to distilled water, deoxygenated by boiling, in a closed bottle and keeping the contents at 40°C . for one day. The solutions were then cooled to room temperature.

The ferric hydroxide was prepared by simultaneously adding equal volumes of 0.1 *N* ferric sulfate and 0.1 *N* sodium hydroxide from burettes to 500 ml. of boiling distilled water, while stirring constantly. The precipitate was then centrifuged and washed until the washings were free of sulfate ion. Chemical analysis of a portion of the precipitate did, however, indicate a trace of sulfate ion.

The cupric hydroxide was prepared in a similar manner, using 0.1 *N* cupric sulfate solution.

The zinc hydroxide was prepared by adding concentrated ammonia to a zinc sulfate solution until the precipitate which first formed was dissolved. Then dilute sulfuric acid was added until the solution was neutral; phenolphthalein was used as the outside indicator. The precipitate of zinc hydroxide was centrifuged and washed until free of sulfate ion.

The 300 ppm. SiO_2 sodium silicate solution was made by adding the correct volume of distilled water to sodium silicate 40°Be. , 1:3.22 $\text{Na}_2\text{O} : \text{SiO}_2$ (HS), while the 10 ppm. SiO_2 solution was made by adding the 300-ppm. solution to water.

Saturated solutions of the hydroxides in sodium silicate solutions were made by adding the washed solid hydroxides, in amounts exceeding that necessary to react chemically with all of the sili-

TABLE 3

Change in Amount of Silica in Saturated Solutions of Ferric, Cupric, and Zinc Hydroxides Containing Solid Hydroxides

Metal Hydroxide	Amount of Silica			
	Interval			
	0 Week	1 Week	3 Weeks	6 Weeks
Ferric Hydroxide	10 292	8.5 228	8.3 228	8.0
Cupric Hydroxide	10 292	9.2 241	9.0 241	
Zinc Hydroxide	10 292	7.4 220	6.6 194	5.3 189

cate, to the sodium silicate solutions, in closed Pyrex bottles, and shaking for several hours. Colorimetric determination of the amount of silica showed that none was removed in the time necessary to saturate the solutions. Only the saturated solution of ferrous hydroxide was used, as it is very difficult to keep the solid from oxidizing. The correct concentration of sodium silicate was therefore made in solution. In one set of experiments, the solutions were centrifuged from the solid hydroxides; in another, the solids remained. The bottles were shaken by hand several times a day; portions were removed at given intervals, and the amount of SiO_2 determined. In the saturated solutions, without any solid hydroxides present, there was no change in the amount of silica.

Table 3 lists the findings in saturated solutions containing solid hydroxides. No reaction was found to take place between saturated solutions of the various hydroxides and sodium silicate solutions. There was no change in the amount of silica even after several

weeks. With the solid hydroxides suspended in saturated solutions, the amount of silica was gradually reduced with time—the greatest reduction taking place in the presence of zinc hydroxide, the smallest in the presence of cupric hydroxide and an intermediate reduction occurring with ferric hydroxide. Moreover, there was a change in the physical nature of the hydroxides after silica had been taken up. From loose gelatinous types they became much more adherent, sticking rather firmly to the bottom of the bottle. This effect was more pronounced in solu-

(galvanized iron) and copper (yellow brass) is necessary before silica can be removed from similar, very dilute sodium silicate solutions. In addition to colorimetric determination of silica, visual observations were made of any film formation, and characteristics of the film were noted. The sodium silicate solutions, containing approximately 10 and 300 ppm. SiO_2 , were made from 40°Be. , 1 : 3.22 $\text{Na}_2\text{O} : \text{SiO}_2$ (HS), and commercial anhydrous sodium metasilicate (LS), as described in previous experiments. The metals were obtained by cutting 1-in. lengths

TABLE 4
Effect on Black Iron, Galvanized Iron and Yellow Brass

Metal	(HS) Sodium Silicate						(LS) Sodium Silicate					
	Silica— <i>ppm.</i>					pH	Silica— <i>ppm.</i>				pH	
	Interval						Interval					
	0 Week	2 Weeks	4 Weeks	6 Weeks	8 Weeks		0 Week	2 Weeks	4 Weeks	6 Weeks		
Black Iron	10	6.6	2.1	0.8		7.9	14.2				9.8	
	292	250	203	152	98	10.0	270	270		270	11.5	
Galvanized Iron	10	3.5	0.8	0.4		7.9	14.2		1.1		9.8	
	292	250	205	144	102	10.0	270	270		266	11.5	
Yellow Brass	10	10	10			7.9	14.2			14.2	9.8	
	292	288	285			10.0	270			270	11.5	

tions with relatively higher concentrations of silica.

Experiment 3

Effect of Sodium Silicate Solutions on Black Iron, Galvanized Iron and Yellow Brass

The previous experiment demonstrated that only solid hydroxides of iron, zinc or copper remove silica from extremely dilute sodium silicate solutions. The purpose of the third experiment was to determine whether or not corrosion of iron (black iron), zinc

of 1-in. diameter pipe and halving them. These pieces were thoroughly washed with soapy water, rinsed with distilled water, heated in alcohol and allowed to dry in the air. A piece of each metal was put into 250 ml. of the sodium silicate solutions in stoppered Pyrex flasks. At given intervals, portions of the solutions were removed and the silica was determined. Table 4 shows the analytical results.

The action of sodium silicate solutions of different concentration on the metals indicated that as solid corrosion products formed the amount of silica

in solution decreased.* Wherever there was no corrosion, no silica was removed from the solution. This refers to the yellow brass which did not corrode within the eight weeks of the experiment. It is known, however, that yellow brass corrodes in service after a period of years to form zinc corrosion products (7), which remove silica from water to form a protective film. The absence of corrosion of iron and zinc, in the high concentration of (LS) sodium silicate solution, was due to the very high pH (11.5) of the solution.

Experiment 4

Chemical Analysis, Microscopical Examination and X-Ray Diffraction Patterns of Films Formed in Yellow Brass and Galvanized Iron Pipe Carrying Hot Water Containing About 8-12 ppm. Silica in the Form of Sodium Silicate

A microscopic study was made of both wet and dry deposits which had formed in brass pipe carrying hot water treated for several years with sodium silicate (8-12 ppm. SiO_2). Both films consisted essentially of amorphous silicic acid in which mineral matter, normally present in water, was embedded. Some quartz particles were found in the dry film, but examination of city water also revealed fine quartz particles similar to those in the dry deposit. The fresh wet film was described as gelatinous. It was concluded that these data indicated the formation of silica gel.

In order to know more about the nature of films formed in pipes carrying

* In identical experiments using colloidal dispersions of silica a similar result was obtained. The fact, however, that even in these colloidal dispersions some ionic silica was found in equilibrium with the colloidal phase, makes it impossible to say which type of silica was being removed.

water with a very low concentration of sodium silicate, chemical analyses were made and X-ray diffraction patterns taken. The films formed in yellow brass and galvanized iron pipes, carrying hot New York City water to which a controlled amount of sodium silicate (8-12 ppm. SiO_2) had been automatically fed for more than a year, were removed. The film in the brass pipe was adherent, tan in color and evenly distributed; that in the galvanized iron pipe was evenly distrib-

TABLE 5

*Chemical Analysis of Films in Yellow Brass and Galvanized Iron Pipes**

Brass Silica + Organic Matter	Percentage
	67
Cu	4
Bi	Trace
Fe	9
Zn	6
Ca	1
Mg	<1
Na	13

No chloride, sulfate or carbonate anions

Galvanized Iron Silica + Organic Matter	Percentage
	63
Cu	Trace
Fe	10
Zn	20
Ca	1
Mg	<1
Na	6

No chloride, sulfate or carbonate anions

* Metals are present as hydroxides or silicates or both.

uted, loose and rust colored, with a number of white blobs. Both films were removed by rubbing the inside of the pipe with a long hard rubber spatula and washing out the slurry.

They were chemically analyzed on a semi-micro scale and the silica and organic matter were estimated by difference. A piece of the white blob in the galvanized iron pipe proved to be $\text{Zn}(\text{OH})_2$. The results of the analysis are given in Table 5.

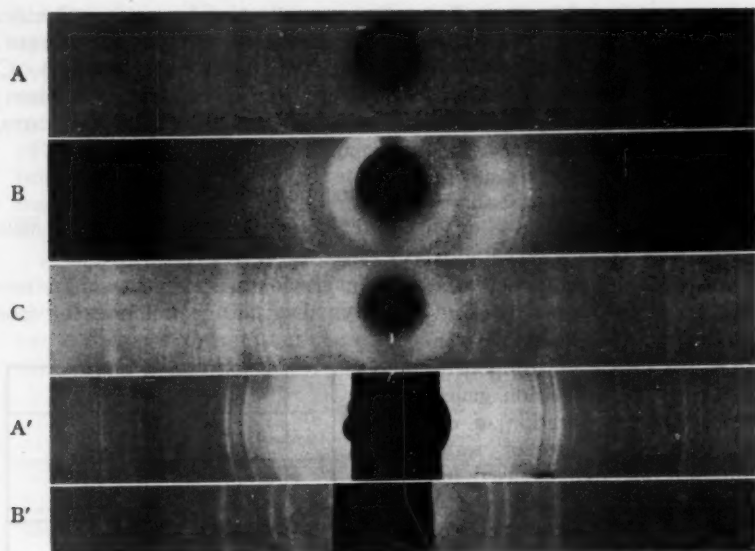


Fig. 3. X-Ray Diffraction Patterns of Films

Each film was formed in water pipes (of the materials indicated by the key below) through which flowed hot water, to which 8-12 ppm. SiO_2 as sodium silicate had been added.

A—Brass (wet film)

B—Galvanized iron (wet film)

C—Brass (dry film)

A'—A, heated at 1,000°C. for 30 minutes

B'—B, heated at 1,000°C. for 30 minutes

Under the microscope at 600 magnifications, both films looked the same, both wet and dry—a honeycomb mesh with brown solid inclusions, and so much brown material (Fe_2O_3) overlaid as often to cover the underlying material. Hot extractions with acids (HCl and HNO_3) removed the overlying brown material, leaving a nearly white residue, which, upon microscopic examination, appeared the same as the white residue found to be silica in the original films.

X-ray diffraction patterns of each film were made by mounting the wet slurry in Pyrex capillaries and irradiating them in a Debye camera. In order to detect the presence of amorphous material, the dry samples were heated at 1,000°C. for 30 minutes. Figure 3 shows the X-ray diffraction patterns of the films.

Their line breadth indicates that the crystalline substances are of the same order of magnitude: 10^{-4} to 10^{-5} cm. All photograms have the same line position and relative intensity, indicating that the crystalline components and their relative abundance are about the same. The most prominent crystalline materials present in samples A and B are $\beta\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ and SiO_2 (quartz). Neither crystalline silicates, hydroxides or oxides of iron (other than those already indicated), nor copper, zinc, calcium and sodium could be detected. Sample A heated (A') shows a strong pattern of copper oxide in addition to those already found. Sample B heated (B') gives a pronounced pattern of zinc oxide in addition to those previously found.

Whether or not these results held for all films formed in galvanized pipes

carrying water with 8-12 ppm. silica was next to be ascertained. The dried deposits from a number of pipes in different buildings were examined visually and analyzed chemically. The duration of water treatment had varied from seven months to twenty years for both hot and cold water.

Surface examination generally showed a thin ($\frac{1}{16}$ – $\frac{1}{8}$ in.) brown coating over an equally thin white one, next to the metal surface. Some had tubercles varying in size and number from a pinhead to growths $\frac{1}{2}$ in. in diameter and $\frac{1}{4}$ in. high. Tuberculation generally increased as the duration of exposure to, and temperature of, water flowing through the pipe increased, but ceased when a silica film formed.

An attempt—not completely successful—was made to separate the upper brown layer of each deposit from the lower white one, in order to analyze each separately. In addition, a whole tubercle was analyzed to see if its formation affects the chemical composition of the deposit.

The results of the chemical analyses of the upper brown layers were about the same as those made on galvanized iron pipe, as given in Table 5. All the lower white layers showed a similar composition— SiO_2 (large), Zn (large), $\text{CO}_3^{==}$ (trace). Some of the metals found in the upper layer were detected in the lower layer in much smaller amounts, but their presence was probably due to imperfect separation of the two layers. Zinc occurred in the lower layer as a hydroxide, or silicate, or both, together with very small quantities of carbonate or basic carbonate.

The tubercle, about one-half in. in diameter and one-quarter in. in height, consisted, internally, of dark red brown material (ferric oxide) with some magnetite. Covering these were the usual white and brown layers, thinner than

those usually found on pipe. Chemical analysis showed: SiO_2 (small amount), organic matter (small amount), Cu (trace), Fe (very large amount), Zn (small amount), Ca (very small amount).

Experiment 5

The Nature of the Removal of Silica by Zinc Hydroxide

In previous experiments it has been shown that silica is not removed from

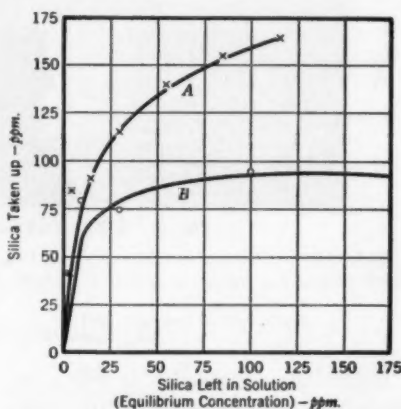


Fig. 4. Silica Removal by Solid Zinc Hydroxide

Curve A represents the ionic silica, as found by subtracting from the silica in the original solution the directly determined silica in equilibrium solution. Curve B represents the total of ionic and colloidal silica, found by subtracting from the silica in the original solution the silica in equilibrium solution, as determined by alkali boiling.

solution until solid corrosion products are formed. The object of the fifth experiment was to determine the mechanism by which solid zinc hydroxide (or hydrous zinc oxide) removes silica. Starting with varying amounts of silica, the concentration left in solution (equilibrium concentration) when the maximum amount is taken up by zinc hydroxide, was determined. By

plotting the equilibrium concentration against the amount removed by the same quantity of zinc hydroxide (original concentration minus equilibrium concentration), a curve was obtained (Fig. 4), which is a typical Freundlich isotherm. This indicated that silica was being adsorbed from solution by the solid zinc hydroxide.

Zinc hydroxide was prepared as described in the second experiment. A specific amount of the hydroxide was suspended in a definite volume of distilled water so that 10 ml. of the thor-

both directly (ionic), and after alkali boiling (ionic + colloidal). The difference between the amount in the original solution and the equilibrium concentration was taken up by the zinc hydroxide. The original sodium silicate solutions used showed about the same quantity of silica determined by both methods. Sodium silicate solutions, refluxed for about the same length of time without solid zinc hydroxide, showed a slight increase in amount of silica, due to the action of the solution on the glass. The quantity de-

TABLE 6
Removal of Silica by Solid Zinc Hydroxide

Experiment No.	SiO ₂ in Original Solution*	SiO ₂ Left in Solution (Equilibrium Concn.)		SiO ₂ Taken up by 120 mg. Zn(OH) ₂	
		Direct	Alkali Boil	Original Soln. Direct	Original Soln. Alkali Boil
	<i>ppm.</i>		<i>ppm.</i>		<i>ppm.</i>
1	45	3	3	42	42
2	90	5	10	85	80
3	105	15	30	90	75
4	145	30		115	
5	195	55	100	140	95
6	240	85		155	
7	280	115	190	165	90

* Direct and alkali boil.

oughly mixed suspension yielded 120 mg. of solid zinc hydroxide (dry basis) after centrifuging. This was added to 200 ml. of (HS) sodium silicate solution, of a known silica concentration, in a Pyrex flask with a glass seal reflux condenser, and boiled. The amount of zinc hydroxide exceeded the amount of silica calculated on a stoichiometric basis. The time required for maximum removal of silica—usually about 48 hours—was determined by centrifuging small portions (10 ml.) of the mixture at given intervals, returning the solid to the flask, and analyzing the centrifugate for amount of silica. The amount of silica was determined

terminated, however, was the same by both methods of analysis. Analytical results are given in Table 6 and shown in Fig. 4.

After the maximum amount of silica had been taken up by the zinc hydroxide (equilibrium solution) the suspensions were centrifuged. Two layers were always observed—a heavier white opaque one on the bottom and a translucent one on top. While the original zinc hydroxide had a plate-like appearance under the microscope (600×), the translucent top layer was characterized by rod-shaped particles. The white opaque lower layer showed a preponderance of plates and a small quan-

tity of rods. The translucent top layer, when shaken in water, produced a silky effect which was not shown either by the original zinc hydroxide or by the opaque white lower layer. Chemical analysis of the upper translucent layer showed that it contained zinc and silica. Although analysis of the opaque white lower layer also showed zinc and silica, the silica was present in lower concentration than in the upper layer. The presence of silica, at all, seemed to be due to some of the upper layer being admixed.

Discussion

A study of the results of Experiment 1 indicates that there is an equilibrium achieved between ionic and colloidal silica. When the original silica concentration is high (700–1,400 ppm. SiO_2), it takes about three days to establish the equilibrium, the shift being from ionic to colloidal silica, as indicated by a drop in the amount of SiO_2 determined directly. In more dilute solutions (14–350 ppm. SiO_2), the attainment of equilibrium is very rapid, probably instantaneous.

Examination of the various solutions for colloidal particles revealed their presence in all solutions regardless of concentration and method of dilution; yet for all solutions up to and including 350 ppm. SiO_2 , the direct colorimetric method found 100 per cent ionic silica. This contradiction is explained by the fact that there is an equilibrium established between ionic and colloidal silica, and, as the ionic silica is removed, the colloidal silica changes to the ionic form. The rapid shift from one form to the other was further shown by the absence of colloidal particles in a 70-ppm. SiO_2 solution after the addition of reagents necessary for direct colorimetric analysis.

The results of Experiments 2 and 3 indicate that solid corrosion products must be present before silica is removed from solution. This was further demonstrated with yellow brass, from which no silica was removed because of its extremely slow corrosion, and with iron and zinc in high concentrations of LS sodium silicate solutions. In these experiments, dilute solutions of sodium silicate (HS and LS), which are predominantly ionic silica in equilibrium with some colloidal silica, were used. In experiments using solutions composed mainly of colloidal silica, which had some ionic silica in equilibrium with it, it was found that the amount of colloidal silica decreased. The fact that some ionic silica was present, however, and therefore could be obtained from the colloidal form, precluded the possibility of stating, on this evidence, which form is most effective in film formation. Thus, it is impossible to state at this point whether silicate ion, simple or complex, or colloidal silica (colloidal electrolyte, ionic micelle) is the activating agent in the formation of a film. Yet the important fact is that silica in some form, regardless of the type originally predominant, is taken up when solid products of corrosion form.

X-ray diffraction patterns, chemical analyses and microscopic examination of the films which formed in galvanized and brass pipe through which water treated with sodium silicate had flowed, give some understanding of the nature of silica in solid corrosion products. The X-ray diffraction patterns (Fig. 3) show that copper and zinc compounds were originally present in samples A and B, respectively, in amorphous form, probably as hydrous oxides or hydroxides. The absence of copper and zinc silicate in the heated

samples would seem to indicate the absence of these compounds originally. Because the most dominant pattern in both heated samples was that for silica (α cristobalite), considerable quantities of it in the unheated samples were evidently in amorphous form. The validity of this type of evidence has already been shown (8, 9). The presence of quartz in the unheated samples came from the normal occurrence of this material in New York City water, as demonstrated by microscopic examination.

These data indicate that the films formed on both metals (brass and galvanized iron) are predominantly amorphous silica (gel), enmeshing small amounts of iron oxide and organic matter normally present in the city water supply. Copper and zinc hydroxides from brass and galvanized iron, hardness from the water and sodium from sodium silicate added, also appear in the silica film. Not only do the films from both kinds of pipe look alike, but there is no marked difference in their composition. Most striking, moreover, is the similarity, in all respects, of the deposits formed in pipes carrying water treated with sodium silicate (8-12 ppm. SiO_2) for from seven months to twenty years.

These findings indicate how the deposit forms in the pipe. Initially, the zinc reacts with the water, eventually forming the solid corrosion product, zinc hydroxide. The zinc hydroxide, positively charged, removes silica, negatively charged, from the water to form a deposit in the pipe. The silica film, being gelatinous, mechanically enmeshes particles in the water. The fact that the water and the film are slightly alkaline, the former from the added sodium silicate and the latter from the zinc hydroxide, accounts for the presence of iron and hardness which

precipitate in the film. The similarity in chemical composition of deposits obtained under different conditions of temperature and duration of treatment, indicates a similar mode of formation.

With the knowledge that the silica in the film was in an amorphous condition as a gel, the next step was to determine the mechanism by which the silica was removed from the water. This was revealed by the results of Experiment 5, in which solid zinc hydroxide was refluxed with sodium silicate solutions of varying concentration. The curve (Fig. 4) is a typical Freundlich isotherm showing either adsorption or solid solution. As there is no displacement of lines in the X-ray diffraction patterns of the film formed on corroding galvanized iron, which gives rise to zinc hydroxide, it is logical to rule out solid solution and to conclude instead that adsorption is indicated. The fact that there is a smaller uptake of silica by solid zinc hydroxide at room temperature (Table 3) than at around 100°C . (Table 6) indicates that the type of adsorption is chemisorption, which results in the formation of a new solid phase (top layer) containing zinc and silica. An analogous situation is found in actual practice when a siliceous film is seen to form much more readily in a hot water than in a cold water pipe.

From the evidence, it is highly probable that silicate is present only on the surface, forming an "adsorption compound" (10, 11). This type of combination has only recently been fully discussed (10, 11) in connection with alumina used in chromatographic studies, and in the reaction of tannin with certain metal salts in solution. The idea of a combination on only the surface of a solid, but not in the interior, forming an independent phase in asso-

ciation with unchanged solid corresponds to the concept of adsorption (11, p. 454), probably chemisorption. The similarity between adsorption of silica by solid zinc hydroxide and "adsorption compounds" is so striking as to offer the most plausible explanation based on experimental results to date.

The film formed on the pipe now can be pictured as a two-layer deposit without a sharp line of demarcation. The lower layer consists of the initial metal corrosion products. The upper layer is a conglomerate of an adsorption compound of silica and the metal hydroxides enmeshed with silica gel, which had extracted compounds of iron, calcium and magnesium from the water.

Summary

Solutions of different sodium silicates in very low concentration (12-1,400 ppm. SiO_2) are shown to achieve an equilibrium between ionic and colloidal silica, the rate being slower as the concentration increases. Silica is not removed from these solutions by metals until the solid corrosion products of the metals form. The siliceous film which forms on the corroding metals and inhibits the corrosion process is identified by chemical analysis, microscopic examination and X-ray diffraction pattern as being predominantly amorphous silica. The mechanism of removal of silica from very dilute solutions of sodium silicate by zinc hydroxide is shown to be adsorption (chemisorption), resulting in the formation of an adsorption compound. A description has been given of the film formed by the adsorption compound in galvanized iron and brass piping during actual service.

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References

1. THRESH, J. C. The Action of Natural Waters on Lead. *Analyst (Br.)*, **47**: 459 (1922).
2. SPELLER, FRANK N. *Corrosion, Causes and Prevention*. McGraw-Hill Book Co., New York (2nd ed., 1935), pp. 359, 366.
3. STERICKER, W. Sodium Silicates in Water to Prevent Corrosion. *Ind. Eng. Chem.*, **30**:348 (1938).
4. HURD, C. B. Studies on Silicic Acid Gels: XIX, Dialysis of Silica Hydrosol and Hydrogel. *Jour. Am. Chem. Soc.*, **68**:61 (1946).
5. ROY, C. J. Silica in Natural Waters. *Am. Jour. Sci.*, **243**:393 (1945).
6. HURD, C. B. Theories for the Mechanism of the Setting of Silicic Acid Gels. *Chem. Rev.*, **22**:403 (1938).
7. POLUSHKIN, E. P. & SHULDENER, H. L. Corrosion of Yellow Brass Pipes in Domestic Hot Water Systems—A Metallographic Study. *Metals Technol.*, **11**:1 (1944).
8. IMHOFF, C. E. & BURKARDT, L. A. Crystalline Compounds Observed in Water Treatment. *Ind. Eng. Chem.*, **35**: 873 (1943).
9. ———. X-Ray Diffraction Methods in the Study of Power Plant Deposits. *Proc. A.S.T.M.*, **43**:1276 (1943).
10. FEIGL, F. The Role of Organic Reagents in the Chemistry of Specific, Selective and Sensitive Reactions. *Adsorption Compounds and Lakes. Anal. Chem.*, **21**:1310 (1949).
11. FEIGL, FRITZ. *Chemistry of Specific, Selective and Sensitive Reactions*. Academic Press, New York (1949), pp. 64 547.

Use of Water by Irrigated Crops in California

By Harry F. Blaney

A paper presented on October 27, 1950, at the California Section Meeting, San Diego, Calif., by Harry F. Blaney, Senior Irrigation Engr., Div. of Irrigation and Water Conservation, Soil Conservation Service, U.S. Dept. of Agriculture.

OF the total land area of California—approximately 100,000,000 acres—about 23,000,000 acres, located in the valley floors, foothills and plateaus, are considered agricultural (1). The remaining three-fourths or so of the state's area is either mountainous with steep slopes, soilless, too rocky for cultivation, barren desert or alkaline flats. Approximately 13,000,000 acres of farm land are available for crops, of which about 6,000,000 acres are irrigated—an amount that represents approximately a quarter of the total irrigated area in the United States. It has been estimated that ultimately about 10,000,000 acres of agricultural lands may be irrigated in the state (2).

Because the water supply of the state is undoubtedly one of its most valuable natural assets, its wise administration and economical use impose upon federal, state, and local agencies one of their greatest public responsibilities. Other natural resources, such as soils, grasses, forests and minerals, may be conserved for future generations, but water, to be of most value, must be used from day to day as it becomes available.

During 15 of the past 20 years, the farm income of California has been higher than that of any other state in the nation, and for the past four years has

averaged approximately two billion dollars annually. This high level of farm activity is largely attributable to, and dependent on, irrigation.

Practically all precipitation in California occurs during the six-month period from November to April, with very little rainfall occurring during the remaining months of the year. This precipitation and the resulting runoff are unequally distributed, with very little relation to regional needs. For example, about 41 per cent of the state's water supply occurs in the north coastal area, which constitutes about 12 per cent of the total area, but ultimately will need only 2 per cent of the water. On the other hand, only 2 per cent of the state's water is found in the south coastal area, which constitutes 7 per cent of the area but ultimately will require 12 per cent of the water.

As in other western states, the availability of water is the chief limiting factor in the expansion of irrigated areas. The increasing cost of new projects is rapidly approaching the maximum expenditure that newly irrigated lands can profitably support. Conservation of existing water supplies, therefore, is of utmost importance in the economy of the irrigated west. The economical use of irrigation water is seldom necessary where water is plentiful, but where

water is scarce, conservation is the rule, and wasteful practices are avoided. It is axiomatic that the most economical use of water exists where there is a diminishing supply and its cost is high. Such conditions prevail in parts of California.

Definition of Terms

The terms "irrigation requirement," "water requirement" and "consumptive use," as used in this paper, are not synonymous. *Irrigation requirement* means the quantity of water, exclusive of precipitation, that is required for crop production. It includes surface evaporation and other economically unavoidable waste. *Water requirement* means to the quantity of water, regardless of source, required by a crop in a given period of time, for normal growth under field conditions. It also includes surface evaporation and other economically unavoidable waste. *Consumptive use* means either the quantity of water transpired and evaporated from a cropped area or the normal loss of water from the soil by evaporation and plant transpiration.

Practically all crops in California require irrigation in varying degrees—the extent ranges from those that need but one or two irrigations to supplement a scanty rainfall, to the high water requirements of forage crops, such as alfalfa and rice, which must be submerged for a considerable part of their growing season.

Data available on the use of irrigation water in California may be divided into three groups. The first group gives the irrigation requirements of certain important crops, based upon soil moisture studies and depth measurements of water applied to field plots, as determined through research studies by state and federal agencies, frequently work-

ing in cooperation with the Div. of Irrigation and Water Conservation of the Soil Conservation Service, U.S. Dept. of Agriculture. The second group of data includes records of depth of water applied (duty of water) in ordinary irrigation practice and estimated irrigation requirements submitted by engineers and water company superintendents. These data are sometimes less reliable than those obtained by experimental measurement; they do, however, cover larger areas and are indicative of the irrigation requirements of most areas in Southern California, where the water supply is limited. The third group includes consumptive use of water by crops, as determined by soil moisture studies, tanks (or lysimeters), analyses of climatological and irrigation data, and other methods. Irrigation requirements may be computed by dividing the consumptive use of water by the efficiency of irrigation.

Water Use

Many factors operate singly or in combination to influence the amount of water consumed by plants, and their effects may differ with locality and fluctuate from year to year. Some involve the human factor, others reflect natural, environmental influences.

The more important of these environmental influences are climate, water supply, soil and topography.

Climate

Because of the mountainous terrain of the state, California boasts an unusually wide range of climatic conditions. Not only are there several different climates within the state, but marked differences in climate occur even within short distances of each other because of peculiarities of local topography. Cli-

matic factors that particularly influence consumptive use are precipitation, temperature, humidity, wind movement and growing season.

During the growing season the amount and rate of precipitation may have a pronounced effect on the quantity of water used for irrigation. Extreme differences in rainfall, as well as in other climatic conditions, occur throughout the state, and the annual precipitation will show a range of from 3 in. in Imperial Valley to 100 in. in the northwestern coastal area. Rainfall is deficient throughout the fertile interior valleys and along the slope of the southern coastal plain, with the greater part of the area receiving less than 20 in. annually and a third receiving less than 10 in. This scanty precipitation, coupled with an almost complete absence of rain during the summer months, makes irrigation necessary for the satisfactory production of crops.

Not all the rain falling upon a field is effective in promoting plant growth. A light rain, falling upon dry soil, will soon be dissipated by evaporation and no benefit will be derived by the plant. If a light rain precedes or follows a heavy rain within a few hours, both storms combined will provide the plant with moisture. Some of the precipitation of heavy storms may be lost by surface runoff. Other storms may be of such intensity and amount that a large percentage of their precipitation will enter the soil and become available for plant transpiration, thereby materially reducing the amount of irrigation water needed and the consumptive use.

The rate of consumptive use of water by crops is probably more affected by temperature than by any other single factor. Abnormally low tem-

peratures may retard plant growth and unusually high temperatures may produce dormancy. Either deviation will influence the amount of water used by the plant. Consumptive use may also vary widely in years of relatively stable temperatures because deviations from the normal seasonal distribution alter the normal rate of plant development. Transpiration, the process by which water vapor is given off by the plant, is influenced, too, not only by temperature, but by the physiologic needs of the plant, both of which vary with stage of maturity.

Evaporation and transpiration are accelerated on days of low humidity and slowed during periods of high humidity. If the average relative humidity is low during the growing season, a greater use of water by vegetation may be expected.

Evaporation of water from land and plant surfaces takes place much more rapidly when there is moving air than under calm air conditions. Hot dry winds and other unusual wind conditions during the growing period will affect the amount of water consumptively used.

The normal length of the growing season in California ranges from 365 days on the extreme southern coast, to less than 100 days in interior mountain districts above the 6,000-ft. level.

The growing season, which is related rather closely to temperature, has a major effect on the seasonal use of water by plants. It is frequently calculated as the period between killing frosts, but for many annual crops it is shorter than the frost-free period, as such crops are usually planted after frosts are past and mature before they recur. Although the growing season may be used as a guide for estimating consumptive use, consideration of the

available data on dates of planting and harvesting, and average annual dates of the first and last irrigation is also important in determining consumptive irrigation requirements.

Water Supply and Soil Types

All of the climatic factors discussed above influence the amount of water that will be consumed in a given area, but other factors can also create important differences in consumptive use. For example, in the arid and semiarid areas of California where irrigation provides the major source of water, both the quantity and seasonal distribution of the available supply will affect consumptive use. Where water is plentiful, there is a tendency for farmers to overirrigate, in both frequency and depth of application. If the soil surface is frequently wet and the resulting evaporation is high, consumptive use will likewise increase. Also, under more optimum soil moisture conditions, particularly with alfalfa, the yields may be higher than average and more water will consequently be used.

It is believed by some investigators that in addition to the quantity and seasonal distribution of the water supply, the quality of the water has an appreciable effect on consumptive use. Whether or not plants require more or less water if the supply is highly saline is debatable. If it is necessary to apply additional water to the land to move the salts down through the soil, however, more water will probably be lost by evaporation from the soil surface, and such loss will be chargeable against the consumptive requirement of the crop.

The agricultural soils of California fall into three general classifications: [1] unweathered alluvial soils, [2] weathered soils developed on uncon-

solidated materials and [3] weathered soils developed on consolidated rock. The first group consists of recent alluvial deposits that are deep, friable and productive. Some are still in process of accumulation. The second group includes the older sedimentary deposits of the valleys, in progressive stages of weathering. These occupy stream and coastal terraces and the more elevated valley plains now undergoing erosion. The third group has been developed on sandstone, shale granitic and volcanic bedrocks, and can be found in hilly and mountainous areas which are susceptible of irrigation only in sections having a more favorable topography and water supply.

The objective in irrigation is to maintain moisture in the soil in amounts adequate for plants to reach maturity and produce a profitable crop. Water available for plant use within the root zone of plants depends on the depth and volume of soil within which roots function, and on the soil texture. Amounts vary for different soils; but, in general, average sandy soils will hold from $\frac{1}{2}$ to 1 in. of available water per foot of depth, sandy loams from 1 to $1\frac{1}{2}$ in., silt and clay loams from $1\frac{1}{2}$ to 2 in., and some clays as much as 3 inches of water per foot of soil. For example, if a 4-ft. root zone in a sandy loam soil should dry down to the wilting point, it would require an irrigation of 4-6 acre-in. per acre to recharge it to field capacity.

Consumptive Use

Consumptive use (evapo-transpiration), as previously defined, indicates the loss of water from the soil through evaporation and plant transpiration. The process by which water vapor is given off by the living plant, principally the leaves, and enters into the atmos-

phere is known as transpiration. It is usually the largest component of consumptive use; direct evaporation from moist soil and water and interception by vegetative cover constitute the remainder.

A large part of the irrigation water applied to farm crops is used in evaporation and transpiration. The remainder is lost by surface runoff from the fields and deep percolation below the root zone. In the widest sense, consumptive use includes all transpiration and evaporation losses from lands on which there is vegetative growth of any kind, whether agricultural crops or native plants, plus evaporation from the bare land and from water surfaces.

Irrigation and consumptive water requirement data are used more and more widely by water superintendents, as well as by federal, state and local agencies responsible for the planning, construction, operation and maintenance of multiple-purpose projects, and by those responsible for guiding and assisting farmers in the solution of their irrigation problems. In order to extend the data available, at various times during the past 46 years, the Div. of Irrigation and Water Conservation and its predecessor, in cooperation with state agricultural experiment stations and other agencies, have measured the evapo-transpiration of specific agricultural crops in various sections of California (3, 4).

Various methods have been used to determine the amount of water consumed by agricultural crops and native (or "natural") vegetation. Whatever method is used, numerous problems are encountered. The source of water used by plants, whether it be precipitation alone, irrigation plus rainfall, or ground water plus precipitation, is a factor influencing the selection of a method.

Until recently, the principal methods used to determine consumptive use have been tank experiments, studies of soil moisture and observations of ground water fluctuations; and, for large areas, the inflow-outflow, effective-heat and integration methods.

Because actual measurements of consumptive use under the various physical and climatic conditions of any large area are necessarily expensive and time-consuming, a rapid method of transferring the results of careful measurements made in spot areas, to other areas with similar conditions, was needed. Several years ago the Soil Conservation Service developed such a method to estimate rates of water consumption. Briefly, the procedure is to correlate existing consumptive-use data with monthly temperature, per cent of daytime hours, precipitation, frost-free (growing) period or irrigation season. The coefficients so developed for different crops are used to translocate or transpose consumptive-use evaluations from one area which has been accurately determined to other areas where only climatological data are available (5, 6).

Although it is recognized that consumptive use of water is affected by numerous independent and related variables, records of temperature and precipitation are by far the most universally available factors in the western States. Fortunately, research studies indicate that of all the climatic factors, these two, together with daylight, undoubtedly have the greatest influence on plant growth. Therefore, although it is recognized that unmeasured factors continue to operate, consumptive use varies in accordance with temperature and daytime hours, and available moisture (precipitation, irrigation and/or ground water). Thus, by

TABLE 1
Seasonal Consumptive Use of Water by Irrigated Crops

Crop and Location	Year	Growing Season	Consumptive Use	Authority
Alfalfa			in.	
Davis	1939	4/1 to 9/30	30.4	Veihmeyer Blaney
San Fernando	1940	4/1 to 10/31	37.4	
Cotton				
Bakersfield	1927-30	4/1 to 10/31	29.2	Beckett and Dunshee Adams and Veihmeyer
Los Banos	1932	5/1 to 11/30	25.5	
Orchard—Citrus				
Azusa	1929	4/1 to 10/31	21.8	Blaney and Taylor Beckett and Pillsbury
Tustin	1929	4/1 to 10/31	20.9	
San Bernardino	Avg.	4/1 to 10/1	25.0	Beckett and Pillsbury Beckett and Blaney
Escondido	1927	4/1 to 10/15	16.4	
Orchard—Deciduous				
Davis	—	3/1 to 11/30	26.4	Veihmeyer Blaney and Taylor
Ontario	1928	4/1 to 9/30	28.4	
Orchard—Walnut				
Tustin	1928	4/1 to 9/30	26.3	Beckett Beckett
Tustin	1929	4/1 to 9/30	27.4	
Truck				
Stockton	1925-28	5/1 to 9/30	21.4	Stout Stout
Stockton	1925-28	4/1 to 10/31	24.6	
Davis (Tomatoes)	1933-35	6/1 to 10/31	22.8	Veihmeyer

multiplying the mean monthly temperature (t) by the monthly percentage of daytime hours of the year (p), one can obtain a workable monthly consumptive use factor (f). It is then assumed that the consumptive use will vary directly with this factor if an ample water supply is available. Expressed mathematically, this will be: $U = KF$, in which U is the consumptive use of the crop or evaporation in inches for any period; F is the sum of the monthly consumptive use factors for the period (sum of the products of mean monthly temperature and monthly percentage of daytime hours of the year); and K is the empirical consumptive use coefficient (irrigation season or growing period).

Even after years of investigation, there are many crops for which no consumptive use measurements have been made. The more common crops in California, including alfalfa, citrus and cotton, have been studied under varying conditions by a number of investigators (Table 1).

Irrigation Requirements

As has been indicated, the irrigation requirements of crops are influenced by such factors as climate, temperature, rainfall, evaporation and length of growing season; by the quantity and cost of the available irrigation supply; by the efficiency of irrigation; by crop characteristics such as rate of

growth and rooting habits; and by soil type. High temperatures, a long growing season and evaporation will increase irrigation requirements while low temperatures and effective rainfall will decrease it. Expensive water will promote high irrigation efficiencies by deterring overirrigation and other wasteful practices. Fast-growing and shallow-rooted crops will require larger quantities of water and mature trees will use more water than young trees. Sandy soils need irrigation more frequently than heavier types. Ground water close enough to the surface to supply capillary moisture to plant roots decreases the irrigation requirement and adequate drainage increases it. These are important considerations controlling the selection of crops and the depth of irrigation required for satisfactory yields.

Adequate determination of the irrigation requirement, as it has previously been defined, is difficult to make in all areas of California because of inadequate data on consumptive use, soil moisture and irrigation efficiency. In 1944-45 Young (7) compiled what data were available on irrigation requirements of California.

Irrigation Efficiencies

In some areas less than a third of the water on hand at the source actually becomes available for use by the crop. This means, for example, that in order to supply 20 in. to crops for actual consumptive use, at least 60 in. (5 acre-ft. per acre) would have to be diverted from a river or other source. Of the unused 67 per cent, a large part is usually made up of transmission and distribution losses in canals, laterals and farm ditches. Application losses—evaporation, deep percolation and surface runoff—account for the re-

mainder. Such losses indicate a need for improvement in the use of available water resources.

Irrigation efficiency is measured by the percentage of irrigation water available for consumptive use by crops. When the water delivered is measured at the farm headgate it is called "farm" irrigation efficiency; when measured at the field or plot it may be designated as "field" irrigation efficiency. Irrigation efficiency determinations have been made by the Div. of Irrigation in cooperation with agricultural experiment stations and other agencies in western states, particularly California (8).

If the farm is small and the farm laterals relatively short, if they are lined, or if the water is delivered to the field by pipelines, farm transmission losses may become negligible and field irrigation efficiency may be approximately the same as the farm irrigation efficiency. Skill in the handling of the water by the irrigator, proper land preparation, and adequate farm irrigation structures may greatly increase the efficiency, with a corresponding decrease in the total amount of water that must be delivered to the land for crop production. Irrigation efficiencies in California range from about 35 to 90 per cent. The higher efficiencies are usually found in southern California areas where the water supply is limited and the cost of water is high. Irrigation requirements may be estimated by dividing the net consumptive use of irrigation water by the irrigation efficiency.

Depth of Water Applied

The Div. of Irrigation and Water Conservation, in cooperation with the state of California, has also conducted studies on the irrigation requirements of different crops (8, 9). Data con-

cerning the depth of water applied (duty of water) in ordinary irrigation practice, and of water delivered to farmers by irrigation systems throughout the state, have been collected (10, 1, 7).

Although there are other factors of importance, the irrigation requirements

crop, grain receives most of its moisture from winter rains. Beans are generally a short-season crop, and, in coastal areas where the climate is cool and moist, may be grown without irrigation, although the use of additional water may improve yields. In the interior valleys beans definitely require

TABLE 2
Seasonal Depth of Water Applied to Typical Crops

Location	Depth of Irrigation Water Applied— <i>ft.</i>					
	Alfalfa	Citrus	Cotton	Deciduous	Grain	Truck
Southern California						
Imperial Valley	4.6		4.0		1.6	2.8
Escondido		1.6				
Vista		1.3				
Riverside		3.0				
Santa Ana		1.5				
San Fernando Valley	2.5	1.8		1.0		1.5
Antelope Valley	5.0					
Ventura	2.0			1.2		
Central California						
Bakersfield	4.0		3.5	1.8	1.5	
Tulare	4.0	2.8	3.3	2.8		
Madera	3.0		2.5	2.5	1.5	3.0
Mendota	4.0		3.5		1.3	3.0
Modesto-Turlock	3.5		2.5	2.0	0.5	1.6
Stockton	3.0			1.8	0.8	1.5
Salinas	2.0			1.3		2.0
Watsonville	2.0			0.8		1.3
Northern California						
Davis	3.0				1.0	
Willows	2.0					
Gridley	3.6					
Dixon	2.9					
Sacramento Valley	3.0	2.0		1.8	0.8	2.0

of crops are closely associated with the length of time between planting and maturity, and the time of year in which they are produced. For most California crops the growing period during which irrigation is required lasts from April through October, although transpiration loss and consumptive use are active somewhat longer. As a winter

irrigation. Alfalfa, another crop, has a long growing season. Because it grows rapidly following each of its several cuttings, it has a high irrigation requirement that does not differ greatly either in the interior valleys or on the coast. In the southern part of the state, the coastal influence is a considerable factor in reducing the water

requirements of crops, whereas in the interior valleys the warmer summers increase the requirements. Typical examples of depth of water applied for various crops in California, under normal conditions, are given in Table 2.

In 1923 the state of California (1) and in 1930-33 the U.S. Dept. of Agriculture (11, 12) made estimates of

in the west may be expected to continue at near the current rate for the next quarter of a century (13).

In 1913 the Div. of Irrigation Investigations* of the U.S. Dept. of Agriculture, in cooperation with the State Conservation Commission, conducted a survey of the irrigation resources of California. Some of the

TABLE 3
Irrigation Requirements in Agricultural Areas

Area	Avg. Net Irrigation Requirement—ft.		
	State*	Federal†	Revised‡
Santa Barbara County	1.5	1.6	1.6
Ventura County	1.75	1.6	1.8
Los Angeles County (coastal)	1.75	1.7	1.8
Orange County	1.75	1.7	1.7
San Diego County	1.25	1.4	1.4
San Bernardino County (coastal)	1.75	1.8	2.0
Riverside County (coastal)	1.75	1.8	2.0
Imperial County and desert lands	3.0	3.1	3.3
Owens and Mono valleys	2.5	2.1	2.3
Sierra foothills—adjacent to San Joaquin Valley	1.75	1.7	2.0
San Joaquin Valley floor	2.0	2.2	2.9
Westside San Joaquin Valley	1.75	1.8	2.0
Salinas Valley	1.75	1.70	1.8
Santa Clara Valley	1.5	1.50	1.5
Delta land	1.5	2.0	2.0
Sacramento Valley floor	2.25	2.1	2.2
Sierra foothills—adjacent to Sacramento Valley	1.5	1.5	1.6
North Coast area	1.25	1.4	1.4
Northeastern mountain valleys	1.75	1.8	1.8

* Reference (1).

† References (11), (12).

‡ Suggested by the author.

the average net irrigation requirements of several typical agricultural areas in the state. These are summarized in Table 3.

Irrigation Development

A limited water supply, combined with the rising cost of construction, is the major obstacle in expanding irrigation agriculture in California. It has been estimated that, with government assistance, the expansion of irrigation

conclusions reached in this preliminary investigation follow (2):

The total area of irrigable agricultural land found in the zones of irrigation water supplies, which include all of the valley lands, the rolling plains of the Great Valley, the arable portions of the Sierra foothills up to about 3,000 ft. in elevation, and all of the plateau and

* Predecessor of the Div. of Irrigation and Water Conservation, Soil Conservation Service.

desert lands to which some irrigation water supplies are available, is 21,865,200 acres, of which 3,192,646 acres are already irrigated, and 9,699,600 acres are estimated as the area to be ultimately irrigated.

Of the total irrigable areas found, about 28.5 per cent are in northern California, about 44 per cent are in central California, and about 27.5 per cent are in southern California. Of the total irrigated area, about 15 per cent is in northern California, about 61 per cent is in central California, and about 24 per

cent are in southern California. Of the total irrigable areas found, about 28.5 per cent are in northern California, about 44 per cent are in central California, and about 27.5 per cent are in southern California. Of the total irrigated area, about 15 per cent is in northern California, about 61 per cent is in central California, and about 24 per

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TABLE 4

Agricultural Area and Irrigated Areas in Southern California Counties, 1899-1939

County	Total Agricultural Area*—acres	Irrigated Area—acres†				
		1899	1909	1919	1929	1939
Imperial	891,110	—	190,711	415,304	432,240	422,834
Los Angeles	1,064,300	85,644	145,586	248,412	205,837	185,380
Orange	278,600	41,549	55,056	87,330	112,025	119,274
Riverside	930,800	32,947	71,436	106,212	135,617	122,040
San Bernardino	1,715,800	37,877	70,278	105,306	108,482	11,0411
San Diego	565,000	16,022	24,944	24,996	42,510	51,664
Santa Barbara	247,300	3,218	12,012	16,335	36,418	42,200
Ventura	211,300	11,935	25,273	31,716	88,519	86,134
TOTAL	5,904,210	229,192	595,296	1,035,611	1,161,648	1,140,567
STATE TOTAL	23,912,100	1,446,114	2,664,104	4,219,040	4,746,632	5,069,568

* Reference (15).

† Reference (14).

cent is in southern California. Of the areas it is estimated may ultimately be irrigated, about 35.5 per cent of the total are in northern California, about 44.5 per cent are in central California, and about 20 per cent are in southern California. Of the estimated future increase in the irrigated acreage of California, about 45 per cent is allotted to northern California, about 36.5 per cent to central California, and about 18.5 per cent to southern California.

In 1936 the National Resources Planning Board estimated the state's ultimate irrigable land, or land avail-

this was expanded to 5,069,568 acres (14). According to the census, 13,419,802 acre-ft. of water were delivered to farm lands in 1939, or 2.64 acre-ft. per acre. Figure 1 illustrates the growth of improved and irrigated farm lands in California from 1860 to date. Although no data are yet available from the 1950 census, it has been estimated that 6,000,000 acres are now under irrigation in California. With an average net irrigation requirement of 2.5 ft., the total irrigation requirement for 1950 has been 18,000,000

acre-ft. of water. On this basis, approximately 25,000,000 acre-ft. of water would be required to irrigate the prospective 10,000,000 acres of farm land in the state. No definite conclusions should be drawn, however, until the state engineer completes the water sources survey, now well under way.

Southern California

The irrigation development in eight southern California counties from 1889 to 1939 and the total agricultural area in these counties are shown in Table 4.

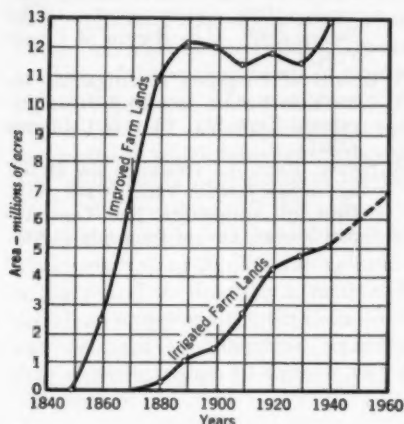


Fig. 1. Growth of Improved and Irrigated Farm Land Area in California

Until the state completes its current survey of land and water sources, any estimate of irrigation requirements for southern California is subject to revision. The results of two previous investigations shown in Table 3, however, have fairly well established the net irrigation requirements per acre under good irrigation practices.

Table 4 shows that the irrigated area in southern California almost doubled from 1909 to 1919, and that from 1919 to 1939, there was an increase of only about 100,000 acres. In some coastal

areas during the latter period, the irrigated crops were replaced by city homes and industrial plants. It is interesting to note that, in 1913, it was estimated (2) that 1,714,200 acres of land in southern California would ultimately be irrigated, of which 879,500 acres would be desert land. The 1939 census indicates that of the 1,140,567 acres irrigated in the southern counties, 511,578 acres were in the desert areas (14). It is conceivable that 2,000,000 acres of land might ultimately be irrigated in southern California if a water supply could be obtained at reasonable cost with the assistance of the state and federal governments. This would require that about 5,000,000 acre-ft. of water be delivered to the farm headgates, or about 2,000,000 acre-ft. more water than was delivered in 1939. Because homes and industries are encroaching upon the present irrigated acreage in some coastal areas, however, it is doubtful that the ultimate irrigated area in the eight southern counties will exceed the estimate made in 1913. It is predicted that the greatest increase in irrigated acreage will occur in desert areas.

References

1. Irrigation Requirements of California Lands. California State Dept. Public Works, Div. Eng. and Irrigation Bul. 6 (1923).
2. ADAMS, FRANK. Irrigation Resources of California and Their Utilization. U.S. Dept. Agriculture, Office of Expt. Sta. Bul. 254 (1913).
3. BLANEY, H. F.; TAYLOR, C. A.; & YOUNG, A. A. Rainfall Penetration and Consumptive Use of Water in Santa Ana River Valley and Coastal Plain. Calif. State Dept. Public Works, Div. Water Resources Bul. 33 (1930).
4. FORTIER, SAMUEL. Evaporation Losses in Irrigation and Water Requirements of Crops. U.S. Dept. Agriculture Office Expt. Sta. Bul. No. 177 (1907).

5. BLANEY, HARRY F. & CRIDDLE, WAYNE D. Determining Water Requirements in Irrigated Areas From Climatological and Irrigation Data. U.S. Dept. Agriculture, Soil Conservation Service, Div. of Irrigation and Water Conservation (1950).
6. BLANEY, HARRY F. & MORIN, KARL V. Evaporation and Consumptive Use of Water Empirical Formulae. Trans. Amer. Geophys. Union (Part I, 1942).
7. YOUNG, ARTHUR A. Irrigation Requirements of California Crops. California State Dept. Public Works, Div. of Water Resources Bul. 51 (1945).
8. BECKETT, S. H., BLANEY, H. F., & TAYLOR, C. A. Irrigation Water Requirement Studies of Citrus and Avocado Trees in San Diego County, Calif., 1926 and 1927. Univ. of Calif., College of Agriculture, Agricultural Expt. Sta. Bul. 489 (1930).
9. BLANEY, HARRY F. & EWING, PAUL A. Irrigation Practices and Consumptive Use of Water in Salinas Valley, Calif. U.S. Dept. Agriculture, Soil Conservation Service, Div. of Irrigation and Water Conservation (1946).
10. BLANEY, HARRY F. & HUBERTY, MARTIN R. Cost of Irrigation Water in California. Calif. State Dept. Public Works, Div. of Water Resources Bul. 36 (1930).
11. FORTIER, SAMUEL & YOUNG, ARTHUR A. Irrigation Requirements of the Arid and Semiarid Lands of the Southwest. U.S. Dept. Agriculture Tech. Bul. 185 (1930).
12. ———. Irrigation Requirements of the Arid and Semiarid Lands of the Pacific Slope Basin. U.S. Dept. Agriculture Tech. Bul. 379 (1933).
13. Irrigation Agriculture in the West. U.S. Dept. Agriculture. Office of the Secretary. Misc. Pub. 670 (1948).
14. Irrigation of Agricultural Lands, California. 16th Census of the United States, 1940. U.S. Bureau of Census (1942).
15. Results of Irrigation Investigations for the Year Ending June 30, 1921. Agricultural Expt. Sta., Univ. of California (1921).
16. EWING, PAUL A. Irrigation and Drainage in San Joaquin Valley, Calif. U.S. Dept. of Agriculture, Soil Conservation Service, Div. of Irrigation (1946).

Determination of Residual Chlorine Compounds

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RECENT advances in chlorination emphasize the importance of accurate methods of determining concentrations of the various kinds of residual chlorine present. In two recent reviews Palin (1, 2) discusses the various methods which have been proposed and describes a new titration method. It is the purpose of this paper to relate the authors' experience with the Palin method in the laboratory and in a plant and to describe a method by which an amperometric titration (3, 4) can be used to determine separately free chlorine, monochloramine and dichloramine.

Palin Method

The Palin method involves a series of titrations with standard ferrous ammonium sulfate solution, using the blue meriquinone color of neutral orthotolidine hydrochloride as indicator. In neutral solution and in the absence of iodide, only free chlorine can be titrated with ferrous ammonium sulfate. When a definite amount of potassium iodide is then added, monochloramine liberates iodine, which, in turn, is titrated with ferrous ammonium sulfate. But when the same sample is acidified to approximately pH 3, dichloramine will liberate iodine. On returning the pH to the neutral range, this is

titrated with ferrous ammonium sulfate to give the dichloramine.

The significance of the three titration increments is based on a comparison with the neutral and acid starch iodide titrations. All other data to substantiate this conclusion are qualitative only. Since it has never been shown that the neutral and acid fractions in the starch-iodide titration quantitatively represent definite forms of available chlorine, it was highly desirable to test the Palin method on solutions using accurately known concentrations of hypochlorous acid, monochloramine and dichloramine.

It has recently been shown (5) that Chapin's data giving the proportions of the several chloramines formed at various pH values are quite accurate for the concentration at which Chapin worked. In a series of experiments at concentrations of 100 ppm. using Chapin's method, the authors have found that pure solutions of monochloramine can be prepared at pH 8.9, while substantially pure solutions of dichloramine can be prepared at pH 4.6. Carefully measured amounts of such solutions and also of pure hypochlorous acid were added to demand-free water to give known concentrations of each compound in order to check the Palin method.

These experiments indicate that the Palin method is qualitatively correct. The hypochlorous acid appears only in Fraction 1, monochloramine only in Fraction 2 and dichloramine only in Fraction 3. With solutions containing only hypochlorous acid, there was good agreement between the Palin method and the calculated chlorine concentration, with some fading of the endpoint when the temperature of the sample was 25°C. or above. With solutions of monochloramine alone, quantitative agreement could be obtained at temperatures in the range of 10°–15°C., but results were very poor in the range of 20°–25°C. Fading of the color was very pronounced and sometimes only one-half of the theoretical residual was found. With dichloramine, the results were very erratic. It was not possible to get consistent agreement at any temperature in the range of 10°–30°C. In all tests, the fading of the color was quite rapid, even though Palin's modification to prevent fading was applied.

Over a period of four months, tests using Palin's procedure were made on a plant effluent carrying chloramine type residuals with water temperatures ranging from 32.5° to 40°F. Very clear-cut endpoints were obtained with no apparent fading, and the results checked excellently with the total residual chlorine concentrations found amperometrically. In a subsequent two-month period, with water of substantially the same quality and temperatures ranging from 70° to 76°F., no definite endpoint in Fractions 2 and 3 could be obtained. Fading was particularly pronounced in Fraction 3. With Fraction 1, which gives the hypochlorous acid content, excellent agreement was found with the amperometric procedure even during this second period of observation. In this test, also,

the use of Palin's citric acid type buffer to inhibit fading gave no improvement in the chloramine determination.

The pronounced fading strongly indicates some reaction between free iodine and orthotolidine in neutral solution, with an irreversible drop in oxidizing power. This observation was confirmed by adding Palin's orthotolidine solution to chlorinated samples, followed by amperometric titration. Even with potassium iodide addition, no active halogen could be detected by titration at neutral pH. Strong acidification of such solutions released about one-half of the expected iodine for titration. This means that the orthotolidine functions not as an indicator but as a mediator. Instead of a single quantitative reaction, there are two series of reactions, either one of which may predominate.

Amperometric Titration

Having previously observed that dichloramine did not liberate iodine at neutral pH, Palin's work encouraged the authors to try Harold's observation (6) as the basis of an amperometric titration method.

Marks and Glass (3) had shown that hypochlorous acid quantitatively reacts with arsenite, while chloramine cannot be titrated with this reagent unless iodide is present. Subsequently Chamberlin and Glass (7) used this amperometric method as a basis for developing a new set of orthotolidine standards. The accuracy and reliability of the method for solutions containing only hypochlorous acid were thus firmly established.

There were some small discrepancies in the results with chloramines as Palin (1) has pointed out. Experiments with dichloramine have shown that it caused such discrepancies. At neutral

pH, it does not liberate iodine from low concentrations of iodide or react with arsenite. It does quantitatively liberate iodine at pH 4. Since monochloramine quantitatively liberates iodine at pH 7, the basis for an amperometric method which will accurately determine all three forms of residual now exists. Free chlorine is titrated with arsenite at neutral pH and in the absence of iodide. Then potassium iodide is added in a limited amount, and the monochloramine is titrated at neutral pH. Finally, the pH is lowered to 4, more potassium iodide added and the dichloramine titrated.

Since sodium arsenite, itself, does not react quantitatively below pH 6, it would be necessary in the final step to raise the pH to neutrality again. Fortunately, it has already been shown (8) that phenylarsin oxide solution acts like arsenite towards free hypochlorous acid and chloramine and, in addition, can be used to titrate iodine at low pH. This reagent can be used in that way to avoid the additional step of raising the pH at the end.

Detailed Method

The following solutions are used:

1. Potassium iodide, analyzed reagent, 50 g. per liter.
2. pH 7 buffer: 35.4 g. monopotassium phosphate (cp.) and 86 g. disodium phosphate (cp.) ($\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$) are dissolved in distilled water and diluted to 1 liter.
3. pH 4 buffer: 480 g. glacial acetic acid and 243 g. sodium acetate trihydrate are dissolved in distilled water and diluted to 1 liter.
4. Standard phenylarsin oxide solution: Approximately 0.8 g. of phenylarsin oxide powder is dissolved in 150 ml. of 0.3 N NaOH. After settling, 110 ml. of this solution is poured off

into 800 ml. of distilled water and thoroughly mixed. The solution is brought to pH 6-7 with dilute hydrochloric acid solution and finally diluted to 1 liter. It is titrated with freshly standardized iodine solution using starch indicator and finally adjusted with distilled water to 0.00564 N. 1 ml. of this solution is equivalent to 0.2 mg. available chlorine (8).

A 200-ml. sample of water is treated with 1 ml. of the pH 7 buffer, if its pH value lies outside the range 6.0-7.5. In an amperometric titration apparatus

TABLE 1
Amperometric Titration of Preformed Monochloramine (25°C.)

Calculated From Dilution	Fraction 1	Fraction 2	Fraction 3
Available Chlorine—ppm.			
0.69	0	0.68	0.01
0.67	0	0.66	0.01
1.28	0	1.25	
0.92	0	0.89	0.03
0.97	0	0.95	0.00
1.93	0	1.86	0.01

(3, 4, 9), it is titrated to an endpoint with standard phenylarsin oxide solution to give Fraction 1. Then to the same sample is added 0.2 ml. of the potassium iodide solution and the titration with phenylarsin oxide is carried again to an endpoint to give Fraction 2. Finally, 1 ml. of pH 4 buffer and 1 ml. of potassium iodide solution are added, and the titration is carried to a third endpoint to give Fraction 3. In the absence of nitrogen trichloride, the number of milliliters of phenylarsin oxide solution in Fraction 1 gives hypochlorous acid in parts per million available chlorine; that in Fraction 2

gives monochloramine, and that in Fraction 3 gives dichloramine, also in parts per million available chlorine.

Supporting Data

Samples of water containing only monochloramine were made up in the manner described above and analyzed by this procedure. Illustrative data are shown in Table 1. At pH 7, monochloramine gives no titration in the absence of iodide but is quantitatively determined at this pH on the addition of 50 ppm. potassium iodide. There is usually a slight additional titration

with 50 ppm. potassium iodide. As the pH goes below 6, the monochloramine begins to titrate in the absence of iodide. At pH 4, practically all of it is obtained. Titrations have been carried out at 1°C. using the recommended procedure, and the results checked with those obtained at room temperature.

Application of the procedure to solutions containing only dichloramine is illustrated in Table 2. None of the dichloramine is titrated at pH 7, either with zero or with 50 ppm. potassium iodide. At pH 4 and with excess potassium iodide, the dichloramine is quantitatively determined. In view of the difficulty of avoiding traces of hypochlorous acid or monochloramine on dilution, the agreement is considered to be very satisfactory. It will be recalled that dichloramine undergoes a decomposition reaction when the pH is raised to 7.

At pH 7, with quantities of potassium iodide much greater than 50 ppm., there is some liberation of iodine by dichloramine. A 250-ppm. amount of potassium iodide causes a reaction of about 10 per cent of the available chlorine. On the other hand, even at pH 4, 250-500 ppm. potassium iodide is the minimum necessary to give quantitative liberation of iodine. Then the reaction proceeds quantitatively at pH values even slightly higher than 4. As the pH exceeds 4.5, the reaction becomes too slow and a quantitative titration procedure cannot be carried out in a reasonable time. Although decreasing the pH to below 4 does not change the effect of dichloramine on potassium iodide, below pH 3.5 oxidized manganese begins to titrate, so that the limits are 3.5 to 4.5. Titrations of dichloramine by the above pro-

TABLE 2

Amperometric Titration of Preformed Dichloramine (25°C.)

Calculated From Dilution	Fraction 1	Fraction 2	Fraction 3
Available Chlorine—ppm.			
0.46	0	0	0.45
0.71	0	0	0.71
0.73	0	0.04	0.68
0.78	0	0	0.80
0.84	0	0	0.84
1.81	0.02	0.07	1.67

increment in the third fraction, due to small amounts of dichloramine which are unavoidable. This, together with the unavoidable loss of a slight amount of chlorine in the process of dilution, makes the agreement between calculated and observed values quite satisfactory. Below 25 ppm. potassium iodide, the titration of monochloramine begins to fall off. Even a trace of potassium iodide gives some titration, so that, in the determination of free chlorine, iodide must be rigidly excluded. As the pH goes above 7.5, the titration gives slightly lower values

cedure at temperatures as low as 3°C. were carried out with the same result as at room temperature.

Application of the method to mixtures of hypochlorous acid, monochloramine and dichloramine in various proportions is illustrated in Table 3. Solutions of the single substances were made up and stored separately. The proper quantity of each was pipetted into 200-ml. demand-free water and the analytical procedure begun immediately. Even though the three compounds were kept separate until the last moment, it was impossible to avoid some reaction, which caused changes in

in the third increment and is counted as dichloramine. The total concentration checks with the total by the starch iodide method.

Following Palin's procedure, solutions were extracted with carbon tetrachloride to remove nitrogen trichloride, and amperometric titrations were performed on the residue. The errors involved are quite large and the extraction procedure is cumbersome. Because nitrogen trichloride is usually present only in small amounts, it is not believed worth while to go through the extraction method for ordinary purposes. It is planned to continue

TABLE 3
Amperometric Titration of Preformed Mixtures of HOCl, NH₂Cl and NHCl₂

Fraction 1		Fraction 2		Fraction 3		Total	
Calculated	Observed	Calculated	Observed	Calculated	Observed	Calculated	Observed
Available Chlorine—ppm.							
0	0.02	0.89	0.97	0.80	0.66	1.69	1.65
0	0.03	0.90	0.92	0.76	0.65	1.66	1.60
0.43	0.30	0.90	1.04	0.76	0.68	2.09	2.02
0.02	0.04	0.68	0.68	0.43	0.28	1.12	1.00

their proportions. For stability, the chloramine solutions had to contain excess ammonia, which always reacted with some of the hypochlorous acid to give monochloramine. There was a loss of dichloramine, both through decomposition and through conversion to monochloramine by reaction with the excess ammonia at pH 7. Considering these complications, the agreement between calculated and observed values is believed to be satisfactory.

With solutions containing only nitrogen trichloride, two-thirds of the chlorine is obtained in the first increment and registers as free chlorine. Practically all the remainder is found

work on a more suitable method for nitrogen trichloride.

Plant Operations

With the plant (10) operating at a high rate of prechlorination, followed by dechlorination with sulfur dioxide to the barest possible quantity of residual chlorine and then by a high degree of postchlorination and also ammonia application, the effect of varying the ratio of ammonia to chlorine was studied by carrying out the differential amperometric titration. Thus, with a ratio of ammonia to chlorine of 1:4, titration of a plant effluent sample showed: hypochlorous acid, 0; mono-

chloramine, 0.61 ppm.; and dichloramine, 0.24 ppm. When the ratio of ammonia to chlorine was changed to 1:3, the titration gave: hypochlorous acid, 0; monochloramine, 0.56; and dichloramine, 0.11. With a ratio of 1:2, titration gave: hypochlorous acid, 0; monochloramine, 0.79; and dichloramine, 0.13. It is seen that the percentage of dichloramine varies from 14 with a ratio of 1:2 to 28 with a ratio of 1:4.

TABLE 4

Monochloramine and Dichloramine in a Distribution System

Date	Plant Sample		System Sample	
	Fraction 2	Fraction 3	Fraction 2	Fraction 3
Residual Chlorination—ppm.				
4-20-50	0.36	0.21	0.26	0.22
4-21-50	0.34	0.18	0.12	0.14
4-24-50	0.35	0.19	0.20	0.15
4-25-50	0.46	0.15	0.19	0.22
4-30-50	0.55	0.24	0.14	0.15
5-1-50	0.31	0.14	0.22	0.21
5-2-50	0.51	0.21	0.17	0.22
5-4-50	0.36	0.19	0.18	0.26
5-5-50	0.31	0.15	0.15	0.17
5-8-50	0.34	0.13	0.11	0.14
5-12-50	0.28	0.11	0.17	0.15
5-15-50	0.59	0.36	0.13	0.13
5-18-50	0.27	0.09	0.12	0.11
5-19-50	0.40	0.16	0.10	0.11

The differential titration was also utilized to determine changes in the relative proportions of monochloramine and dichloramine in the distribution system. One sample a day was taken from a sample tap at the plant, and at the proper time a corresponding sample was taken at a point near the end of the system. A summary of these results is given in Table 4. Fraction 2 is monochloramine and Fraction 3 is dichloramine. Throughout, Fraction 1

was zero. It is seen that in all instances the monochloramine concentration decreases at a more rapid rate than the dichloramine. This results in an increase in the percentage of dichloramine, since the total residual chlorine always decreases. The apparent increase in concentration of dichloramine in a few tests may be within the limits of error due to imperfect synchronization of the two samples. It is commonly thought that dichloramine is a more reactive substance than monochloramine so that this result is perhaps unexpected. On the other hand, the differential method itself is based on the fact that monochloramine reacts much more readily with iodide ion than does dichloramine. It is possible that there are other compounds, some of which may exist in a water supply, that react more readily with monochloramine.

This change may also be related to the decrease in the ammonia-nitrogen content of the water as it proceeds through the system. In the water system studied, the ammonia content usually drops to about one-quarter of its original value by the time the end of the system is reached. This, of course, will tend to cause monochloramine to change to dichloramine, because it changes the ammonia-chlorine ratio.

It is believed that these data illustrate a very important application of such a differential method. There is a definite indication that disagreeable tastes and odors are more likely to be encountered when the residual chlorine is mostly in the form of dichloramine than when it is monochloramine.

In the plant under study, the differential method also is very useful as a guide in the dechlorination with sulfur dioxide. Since the latter removes chlorine but not ammonia, the degree

to which the water is dechlorinated at any one time will have an effect on the ultimate chlorine-ammonia ratio and, therefore, on the relative proportions of monochloramine and dichloramine. Consequently, the use of the differential method to determine these proportions affords a relatively reliable control of the dechlorination process.

Conclusions

The Palin titration method appears to be a very useful qualitative procedure for detecting the various forms of available chlorine. In the determination of hypochlorous acid, the method is accurate and reliable. As applied to the determination of the monochloramine fraction, the precision and reliability of the method are satisfactory at lower water temperatures, but at higher temperatures the method becomes unsatisfactory. In determining dichloramine, the method is somewhat erratic quantitatively at low temperatures and is not usable at temperatures in the neighborhood of 25°C.

The amperometric titration method can be modified by proper control of the iodide ion concentration and pH, so that hypochlorous acid, monochloramine and dichloramine can be precisely and quantitatively separated.

The differential titration is found to have useful applications, inasmuch as it yields detailed information on the results of any given program of chlorination. This could be a very important factor in operating a plant, since the proportions of monochloramine and dichloramine are reliable indicators of the

effectiveness of chlorination and are also important in determining the quality of the finished water.

References

1. PALIN, A. T. The Estimation of Free Chlorine and Chloramine in Water. *J. Inst. Wtr. Engrs.*, **3**: 100 (1949).
2. ———. Chemical Aspects of Chlorination. *J. Inst. Wtr. Engrs.*, **4**:565 (1950).
3. MARKS, HENRY C. & GLASS, JOHN R. A New Method of Determining Residual Chlorine. *Jour. A.W.W.A.*, **34**: 1227 (1942).
4. HALLER, J. F. & LISTEK, S. S. Determination of Chlorine Dioxide and Other Active Chlorine Compounds in Water. *Anal. Chem.*, **20**:1 (1948).
5. MORRIS, J. C.; WEIL, I. & BURDEN, R. P. The Formation of Monochloramine and Dichloramine in Water Chlorination. *Am. Chem. Soc., Div. Water, Sewage & Sanit. Chem.*, Detroit, Mich. (1950).
6. HAROLD, C. H. H. 29th Annual Report on the Results of the Chemical and Bacteriological Examination of the London (England) Waters for the Twelve Months Ended 31st December, 1934. Metropolitan Water Board, London, Eng. (1935).
7. CHAMBERLIN, N. S. & GLASS, J. R. Colorimetric Determination of Chlorine Residuals up to 10 ppm. With Orthotolidine. *Jour. A.W.W.A.*, **35**: 1065, 1205 (1943).
8. MARKS, H. C.; JOINER, R. R. & STRANDSKOV, F. B. Amperometric Titration of Residual Chlorine in Sewage. *Wtr. & Sew. Wks.*, **95**:175 (1938).
9. MARKS, H. C. & BANNISTER, L. G. Amperometric Methods in the Control of Water Chlorination. *Anal. Chem.*, **19**: 200 (1947).
10. WILLIAMS, D. B. A New Method of Odor Control. *Jour. A.W.W.A.*, **41**: 441 (1949).

Elements of Filter Design

By Richard Hazen

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WITHOUT attempting to offer a complete hydraulic analysis of filtration or filter washing, or to duplicate the many detailed studies of filtration theory and operation which have been published, this paper concerns itself with filtration media, underdrain systems, rates of filtration and surface wash systems. Only the design and construction of the filters themselves are discussed, and no consideration has been given to coagulation, sedimentation or other phases of water treatment.

Rapid sand filters, like other products of industrial endeavor, can assume a variety of shapes and manufacturers' labels and still produce the same net results, as the advantages or shortcomings of various special features are offset by complementary qualities. It must be admitted that the personal preferences of the designer have much to do with the design of any filter. On the other hand, well designed filters can be improperly built or operated, and can thus fail to give satisfactory service. The best of plans, despite all the wonders of modern technology, can be defeated by being poorly executed.

A great many filter plants turn out good water, require small amounts of wash water, have relatively long filter runs, and are kept in reasonably

good operating condition. Many other plants, however, have comparatively short lives because the backwashing system disturbs the gravel and sand beds. There is a wide divergence of opinion on what constitutes a satisfactory life-span for a rapid sand gravity filter. In many industrial installations, it is expected that a filter will need to be rebuilt every three to five years, or at most every ten years. If filtration follows lime-softening, the filter sand invariably picks up calcium carbonate, and frequent renewal is necessary.

In other plants, however, there is no reason why a filter, if designed properly and built of sufficiently durable materials, should not last almost indefinitely. The author knows of many plants that have been operating 25 years or more, in which the filter material and underdrain systems are just as good today as they were when the plant was built.

Aside from general clogging caused by inadequate backwash, the failure of a rapid sand filter is usually indicated first by the escape of sand into the clear well, or by the appearance of fine gravel on top of the sand. These symptoms are the result of concentrated flow of water in one part of the filter, during backwash, which has caused the sand and gravel layers to

mix. In the early days of filtration, wire screens were placed between the gravel and sand layers to prevent such mixing, but the screens corroded, and later experience showed them to be unnecessary. Proper design of an underdrain system and of the supporting gravel layers, if any are used, depends essentially on an evaluation of the best method of backwashing the sand uniformly without causing mixing of gravel and sand.

Underdrain Systems

The success of a rapid sand filter depends as much upon proper design and construction of the underdrain system as upon any other single factor. The purpose of the underdrain system is to collect the filtered water and distribute the backwash water. Hydraulic requirements for backwashing are much more severe than those for collecting filtered water, and an underdrain system that is satisfactory for backwashing will always perform the latter function adequately.

The several types of underdrain systems in common use today are illustrated in Fig. 1. They include: [A] header and perforated laterals; [B] header and perforated laterals with precast concrete block between the laterals (Wagner block); [C] vitrified tile block with orifices and water passages to take the place of laterals (Leopold bottom); [D] false bottom, precast or otherwise; flat bottom with strainers or inverted pyramid, such as the Wheeler bottom; and [E] porous plate.

The header and perforated lateral type of underdrain system, with orifices discharging downward against the filter floor, has been standard in water works practice for many years. It is

still competitive in cost and will give satisfactory service if properly designed. Wagner blocks may be added to take the place of the coarse gravel layer, but the underdrain remains basically the same.

The Leopold bottom substitutes glazed tile waterways for lateral pipes, and a number of small orifices in the tops of the tile blocks take the place of comparatively few but large orifices facing down. The Leopold bottom is the only underdrain system with orifices discharging upward that provides no safeguard, other than that afforded by the layer of coarsest gravel, against upward velocities that would upset the filter. Where wash water is discharged through a few orifices, it is essential that some means be provided for deflecting the water downward or side-ward. Several umbrella type strainers have been developed for this purpose. Strainers of any kind are used only to a limited extent in modern design except in small filters or to take care of wash water orifices along main headers, where upward discharge cannot be avoided. The function of the strainer is, essentially, to prevent the concentration of a high velocity vertical rise. Special internal mechanisms that provide different cross sections for filtration and for backwashing seem entirely unnecessary.

In the Wheeler bottom, large spheres in the inverted pyramid are counted on to break up the high velocity; placing the sphere over the orifice assures proper dispersion of the water.

Strainers or deflectors can be blown off a main header or the false bottom, and at one plant where this occurred a high velocity jet worked its way through the gravel and forced some of the fine gravel out on top of the sand.

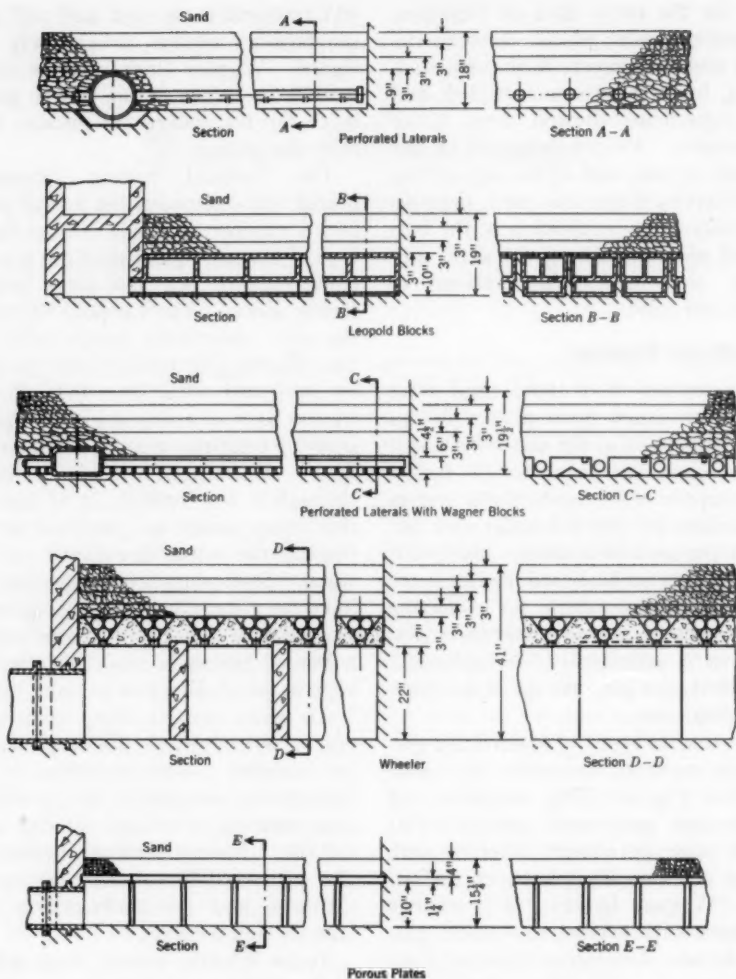


Fig. 1. Filter Underdrains in Common Use Today

- A. The perforated lateral underdrain is characterized by orifices discharging downward against the filter floor.
- B. The Leopold block underdrain uses glazed tile blocks, with passages for the water, instead of lateral pipes.
- C. The Wagner block system uses cement-lined cast-iron laterals located between pre-cast concrete blocks.
- D. The Wheeler bottom is characterized by inverted, truncated pyramids, with the water connection at the apex, and the pockets filled with cement or glazed earthenware spheres.
- E. Porous plates of vitrified or fused crystalline aluminum are designed to provide an even upward velocity over the entire filter bottom. The plates are placed either to provide a false bottom or on top of the concrete channels.

Fortunately, the failure was discovered promptly and it was possible to dig down into the underdrain system, replace the strainer, and then replace the gravel layers and the sand without disturbing too large an area of the filter. A sheet steel coffer dam was used very effectively to do this work.

The porous plate underdrain is designed to provide an even upward velocity over the entire filter bottom. The only porous type in common use is made of vitrified or fused crystalline aluminum, more familiarly known as carborundum. The porosity of this plate is equivalent to the usual layer of fine gravel; and unless plates are badly clogged, there should be no concentration of velocity in any one section of the filter.

The header and lateral system with cement-lined cast-iron pipes used to be the least expensive type of underdrain. A few years ago, however, development of forms which can be rented from manufacturers has reduced the cost of casting Wheeler bottoms to such an extent that they are competitive in nearly all installations. General acceptance of the several types of underdrain systems is indicated by the fact that many engineers, in recent years, have taken bids on alternate arrangements, with final selection based on lowest cost. In such competition, the Wheeler bottom has generally proved the least costly, followed by the header and lateral system, with or without Wagner blocks, and the Leopold bottom.

It will be noted from Fig. 1 that, except for the porous plate underdrain and the Wheeler bottom, there is very little difference in the total depth of underdrain systems from the bottom of the filter box to the top of the finest

gravel layer. The chief purpose of the special underdrains is to use some other means for breaking up the wash water than a fairly thick layer of coarse gravel. This is important in locations where coarse gravel of good quality can be obtained, but where the larger sizes contain too much soluble material. The A.W.W.A. specifications for filter materials (1) recognize this difficulty in allowing greater acid solubility for large size gravel. In many parts of the country where waters are not aggressive, or where the filter is to be used following lime-softening, acid solubility of sand and gravel is of no importance.

The cost of Wagner blocks to replace a filter of moderate size is about 50 cents per square foot. If it is assumed that the blocks displace 8 in. of gravel, the saving is equivalent to about \$20 per cubic yard, or \$15 per ton of gravel. In some parts of the country, coarse gravel of good quality would cost considerably more. Direct comparisons cannot be made for other underdrain systems because of such other factors as the economies resulting from the elimination of piping.

The open space below the false bottom underdrain, sometimes claimed as an advantage, is of more theoretical than practical use. When a filter needs repair, it invariably has to be repaired from the top, and access to its underside is generally of little benefit.

For a filter to operate satisfactorily over a period of many years, it is necessary that the underdrain system be built of durable material. Sometimes it is expected that the water to be filtered will not be very corrosive and, therefore, that special care is not required. Allowances must be made, however, for changes in chemical treat-

ment of water which may take place in the future, and emphasis must therefore be placed on materials that will be least subject to corrosion.

Cement-lined cast-iron pipes, with or without bronze throat pieces or orifices, have been used successfully for many years, and a life-span of 25 years or more for this type of pipe is not uncommon. Wrought-iron laterals with brass strainers are not ordinarily used today, except in very small installations, because the pipe will almost certainly corrode and fail. Perforated copper and stainless steel pipes are also used in some plants. In one fairly small plant, stainless steel pipe was used to replace asbestos-cement laterals which had failed after ten years' use. Service conditions were unusually severe, however, the water being coagulated at a pH between 3.8 and 4.0. Oddly enough, although the 3-in. laterals failed, the 6-in. asbestos-cement pipe, carrying the same water, was in perfectly good condition. There is some evidence that the quality of asbestos-cement pipe manufactured at the time the filter underdrains were installed was not as satisfactory in small as in large diameter pipe.

Glazed tile used in the Leopold bottom should outlast the concrete in the filter box if the joints are satisfactory. The author has had no experience with this, but, as far as is known, durable material is being used.

The life of Wheeler bottoms has been shown to be satisfactory, but Portland cement spheres, in common use twenty or thirty years ago, cannot be considered permanent. At the Charleston, S.C., filter plant, the 3-in. spheres were badly worn out-of-round, after approximately twenty years' use, and had to be replaced. It is difficult to de-

termine whether this degree of wear occurred because of unequal flow around the spheres or because of differences in the hardness of the materials. It is possible that some undersized spheres were started in motion and were gradually worn down by abrasion. Porcelain is usually used in modern construction for large diameter spheres and glazed earthenware for small diameter spheres.

Although porous plate bottoms have given satisfactory service for periods of fifteen years or more, difficulties have been experienced with the anchor bolts and other parts supporting the plates and holding them down during backwash. Although the theory is not yet fully substantiated by experience, it is believed that the relatively small openings in porous plate are subject to clogging and therefore that the useful life of a porous plate bottom will probably be determined by the rate of clogging. By contrast, a conventional filter, with gravel layers and perforated underdrains, provides constantly increasing void spaces from top to bottom. Any material that passes through the sand will proceed on through the gravel and into the clear well. Gradual clogging of a porous plate bottom gives evidence that some material is caught in the fine pore spaces. Reports indicate that loss in head through porous plates during backwashing sometimes increases from as little as 1 to 2 ft. to as much as 5 ft. in a few years. Since no gravel is used with most porous plate installations there is no danger of sand and gravel layers mixing.

Wash Water Distribution

Probably the most common cause of failure in filters is an uneven distribu-

tion of wash water. This results in movement of sand from one part of the filter to another and, ultimately, in a mixing of sand and gravel. In the design of underdrain systems, allowance is made for a head loss through the orifices of from 8 to 10 ft. at normal rates of backwash. This loss in head is obtained by using relatively small orifices spaced 8 to 12 in. apart. A large head loss through the orifices increases the cost of pumping wash water slightly, but in the author's experience it is the one positive way in which to obtain relatively uniform backwash.

The need for a reasonably large loss in head through the orifices can be explained quite simply. If, for example, the total head loss in backwashing is 12 ft., including a loss of 8 ft. through the orifices, the most extreme variations of loss, through the sand and gravel, would still leave a maximum ratio of 12:8 for head losses in various parts of the filter. Because the quantity of water delivered through an orifice will vary to the extent of the square root of the head, the maximum variation in wash water delivered to any part of the filter would be approximately 25 per cent. Usually this variation is not sufficient to cause any lateral movement of the sand. Head loss through the orifices is determined by the ratio of total orifice openings to the gross filter area. Head loss with various openings for a 24-in. and 30-in. backwash are shown in Fig. 2. The percentage of filter area which the orifice openings occupy in the Wheeler and Leopold bottoms, and in other common arrangements, are also shown.

It is difficult to say precisely how low a head loss through the underdrain system can be tolerated before shifting

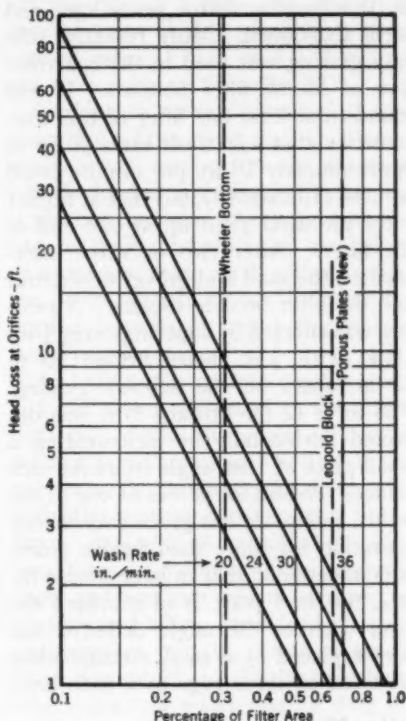


Fig. 2. Head Loss Through Underdrain Orifices

The head loss is given for various rates of wash. The correspondence between orifice diameter and percentage of filter area, when one orifice is used per sq.ft., is as follows:

Orifice Diam., in.	Filter Area, %
$\frac{1}{8}$	0.03
$\frac{3}{16}$	0.08
$\frac{1}{4}$	0.14
$\frac{5}{16}$	0.21
$\frac{3}{8}$	0.31
1	0.55
$1\frac{1}{2}$	0.85

of sand will take place. Slat bottoms, providing no resistance to flow and, theoretically, an opportunity for completely uniform backwashing, were tried

in Washington many years ago, and were abandoned. More recently, subway grating was used in the construction of Morse filter bottoms. It was found in at least one filter of this construction that backwash rates of up to approximately 18 in. per minute could be used satisfactorily, but that at higher rates the sand piled up at one end of the filter. After two or three backwashes, the sand and gravel would mix and the filter become useless. A remedy was effected by superimposing $\frac{1}{4}$ -in. plate, with $\frac{1}{4}$ -in. holes drilled 10 to 12 in. apart on the subway grating. The force of the upward flow was deflected horizontally by tack-welding a small piece of 1-in. angle iron over each orifice. Except for failure of one of the welds, this plant has given satisfactory operation for more than twelve years. It is understood that in later Morse filters, the steel plate is of standard design, whereas the angle deflector has been replaced by a small circular plate mounted on three pegs over each hole.

Filter Media

Discussion of filter media will be limited to the fine material, but a brief comment on the top layer of gravel is also in order. This gravel must be fine enough to support the sand during filtration, yet coarse enough for stability during backwash. In some filters, the top gravel layer is much finer than necessary, and consequently is moved by the backwashing. Although the A.W.W.A. specifications (1) permit gravel sizes as fine as $\frac{1}{16}$ in., the author prefers to use slightly coarser material, having found that sizes ranging from $\frac{1}{8}$ to $\frac{1}{4}$ in. will withstand any normal backwash rate. The stability of the top gravel layer can be checked by backwashing before the sand layer has

been added. If it moves at all, it will move just as much after the sand is in place. If it remains in place, there should be no mixing of the sand and gravel.

The use of relatively coarse sand in filters is the rule rather than the exception today. Coarse material has certain advantages over fine material; it is more easily washed and gives longer filter runs between backwashes. It is not as effective, however, in removing very fine material from the water, as it provides less surface area per unit of volume than fine sand. As long as water is properly coagulated and the floc is strong enough so that it does not break up excessively during filtration, however, coarse filter sand can be used satisfactorily. But if pretreatment is not good, and fine or colloidal material may enter the filter from time to time, finer sand is preferable.

Angular materials, such as anthracite coal or certain types of sand, have greater porosity than well rounded sand particles and will give results similar to coarse sand. The longer filter runs attributed to anthracite coal are largely due to the greater porosity of the angular material.

Sand and anthracite coal are the only two materials used extensively in rapid sand filters today. Sand is much more widely used than coal, although many users of coal are satisfied that it washes more easily, gives longer filter runs, and, in general, is a much more satisfactory filter medium. The principal virtue of anthracite coal is, of course, its low density, which permits the use of very much lower backwash rates. Normal sand has a specific gravity of approximately 2.65, whereas anthracite coal has a specific gravity of only 1.55. This means that backwash rates 30-40

per cent lower than those required for sand will be adequate for anthracite. This is of particular advantage in old filter plants where underdrain systems and wash water facilities are inadequate, and high backwash rates cannot be obtained. Theoretically, the same advantage is offered in the design of new plants. Nearly all new plants are designed with the eventual installation of sand in mind, however, even though coal may be used at the outset. All piping and equipment, therefore, have to be made large enough to provide the maximum backwash rate needed for sand, and throttling is necessary when the anthracite is backwashed. Thus no saving is actually realized.

Anthracite contains no silica and water can therefore be filtered through it without any silica pickup. This is important for certain industrial supplies, particularly for boiler feedwaters, in which silica would be harmful. Some users also claim that anthracite coal is less susceptible to accumulation of grease and other substances that stick on the sand. The point may be made, however, that material which will stick on sand but pass through anthracite may be objectionable in the finished water.

Filtration Rates

Any discussion of filtration rates is essentially a discussion of safety factors. For years rapid sand filters have been designed to process 2 gpm. of water per sq.ft. of filter area. Recently, however, several large plants have been designed for considerably higher rates. The Springwells plant at Detroit, built in 1929-31, was designed for a normal operating rate of 2.6 gpm. per sq.ft. The new Chicago plant was designed for a normal op-

erating rate of 3 gpm. per sq.ft., and several units of this plant have operated at rates as high as 4 and 5 gpm. per sq.ft. without difficulty (2).

Nothing is more discouraging than operating a filter plant that is too small when water coming on the filters is heavily loaded with floc. Frequently, it reaches the point where the operator has to decide whether he can afford to waste any more wash water to clean the filters so that he can continue operation; sometimes it is better to save the wash water.

As long as the pretreatment is good, and the water delivered to the filters does not contain an excess of floc, or the floc is strong enough so that it will not seriously penetrate the filter sand, high filter rates are satisfactory. Sometimes, in order to attain these ideal conditions, relatively high chemical doses and auxiliary agents, such as clay or activated silica, are added to assist precipitation and to obtain a strong floc. Generally, in the larger plants, where the raw water quality does not vary too seriously and adequate supervision is provided, good pretreatment can be maintained at all times and there is no reason not to use high filter rates. In the smaller plants, or in plants where the raw water quality may change suddenly, there is ample reason for permitting poor pretreatment, as it may cost more to assure good pretreatment than to provide some leeway in filter capacity.

If activated carbon is added to the water immediately before it enters the filters, low filter rates may be necessary. Heavy doses of carbon have sometimes passed through filters into the clear well. This condition can sometimes be avoided by using the carbon together with a coagulant, so

TABLE 1—Filter Design Characteristics of Selected Typical Plants

Filter Plant	Source	Underdrain		Gravel		Filter Medium				Filtration Rate		Wash Rate (Sand Rise)		Surface Wash		
		Diam. in.	Orifice	Depth in.	Top Layer Size	Bottom Layer		Top Layer	Total Depth in.	De- sign	Max.	Nor- mal	Max.			
			Opening — % of Filter Area			Depth in.	Effective Size mm.								Effective Size mm.	
Nottingham (Cleveland, O.)	Havens & Emerson	1	0.31	15	1 1/2 in.	Sand	3	0.8-1.2	24	0.4-0.5	27	2.5	3.0	24	36	Palmer
Chapel Hill, N.C.	W. C. Olsen	1	0.31	12	—	Sand	—	—	—	—	27	2.0	2.4	30	40	Palmer
Moore's Br. (Norfolk, Va.)	Whitman, Re- quardt & Assoc.	1/2	0.65	10	—	Sand	—	—	—	0.54	24	2.0	3.0	26	39	Palmer
Wichita, Kan.	Black & Veatch	1	—	21	No. 8-4	Sand	3	1.0-3.0	24	0.47-0.52	27	2.0	3.0	24	30	None
Shreveport, La.	Black & Veatch	1/2	0.65	10	No. 8-4	Sand	3	1.68-2.38	24	0.42-0.50	27	2.0	3.0	24	30	None
Metro. Water Dist. S. Calif.	W. W. Ault- man	1	0.26	24	1-1/4 in.	Sand	4	1.0-1.5	20	0.45-0.50	24	3.0	4.0	28-30	36	Header & lateral
Groton, Conn.	Metcalf & Eddy	1/4	0.21	18	No. 12-1/4 in.	Sand	—	—	30	0.45	30	2.0	3.0	—	36	Prov. for future
Wilmington, Del.	Metcalf & Eddy	1	0.31	12	No. 12-1/4 in.	Sand	—	—	30	0.45	30	2.0	2.5	—	36	Palmer
Monroe, Mich.	Drury, Mc- Namee & Porter	1/2	0.65	6	No. 10-1/4 in.	Sand	—	—	30	0.55-0.65	30	2.0	3.0	—	36+	Palmer
Dallas County, Texas	Powell & Powell	1/4	0.21	14	1-1/4 in.	Anthra- cite	—	—	24	0.60	24	3.0	5.0	18-24	36	Palmer
Niagara Falls, N.Y.	Greeley & Hansen	1/2	0.65	8	1-1/4 in.	Sand	5	0.8-1.2	22	0.50-0.55	27	2.0	3.0	—	30	Palmer
Erie, Pa.	Chester Engineers	1	0.31	12	No. 10-1/4 in.	Anthra- cite	—	—	30	0.68-0.74	30	2.0	3.0	—	32	Palmer
Monroe, La. (add.)	Malcolm Pirnie Engrs.	1	0.21	18	1 1/2 in.	Sand	—	—	24	0.45-0.55	24	2.0	2.5	24	30	None
Springwells (Detroit, Mich.)	E. A. Har- din (3)	0.504	0.28	18	1 1/2 in.	Sand	—	—	20	0.5	20	2.56	2.88	30	39	None
Chicago, Ill.	J. R. Bay- liss (2)	1/4	0.21	21.5	1 1/2 in.	Sand	—	—	24	0.65	24	2.5	4.0+	20	24	Header & lateral

* Alternate bids obtained on Wheeler and porous plate.

that most of it will settle in the basin, and the amount carried to the filters will be relatively small. In some cities, however, use of carbon with a coagulant requires a good deal more carbon for taste removal than can be economically justified. Experience in Oklahoma City, where large quantities of carbon have been required for taste control from time to time, has indicated the advisability of designing additional filters at the more conservative rate of 2 gpm. per sq.ft.

A review of the design data of several recent filters indicates that, while higher rates are being provided for in some plants, most designs still hold fairly closely to 2 gpm. per sq.ft. as normal ratings.

Surface Wash

Filter design data collected in the last few months have demonstrated a distinct trend toward surface wash equipment of the Palmer type. Extensive use of this type of equipment certainly testifies to the adequacy of a simple, well designed device.

Surface washing is sound both in theory and practice. A high rate of backwashing will lift the filter sand and otherwise cause a great deal of agitation, but the higher the wash rate is, the greater will be the distance between sand grains at the surface. The rubbing action and the consequent effectiveness of the washing are thus decreased, allowing some material to accumulate on the sand and leading in turn to the formation of mud balls. By applying a horizontal jet to the surface of the sand, it is possible to introduce a high velocity at right angles to the upward flow. The resulting turbulence and friction between sand grains is thus increased. A surface

wash system can be improvised, if water is available at sufficient pressure, simply by using a garden hose during the wash. This usually means standing in the wash water gutters, however, making effective operation difficult.

In several of the larger, recently constructed plants, including those of the Metropolitan Dist. of Southern California, Chicago and Des Moines, fixed surface wash water systems, consisting of headers and nozzles discharging at intervals over the entire filter area, have been installed. This system is effective, but requires a higher rate of water delivery. With the Palmer system, water is applied at a high rate to only one small area at a time. The Palmer wash requires $\frac{1}{2}$ gpm. at 40 psi. per sq.ft. of filter; this is equivalent to an upward velocity of 0.8 in. per minute. The Metropolitan Dist. plant surface wash system requires the equivalent of 5 in. per minute.

A surface wash will normally help keep a filter clean, particularly if the filter is subject to heavy loading or if the material filtered out is very sticky. The author has seen surface wash most effectively used in a plant where limited settling tank capacity caused floc carryover most of the time. In another industrial plant, where very little alum was used much of the time, and the sand quickly became black and dirty, surface agitation considerably improved the situation. There are many filters, however, that stay clean without surface wash and it may be necessary only to draw down the water three or four times a year and remove material from the top. In such plants, of course, there is little justification for including a surface wash system.

About 20 years ago, when planning the design of the Springwells plant at Detroit, E. A. Hardin (3) collected design data from more than 60 filter plants in the United States. The collection of more recent data on fifteen selected plants, listed in Table 1, although not sufficient for an accurate statistical summary, does permit some comparison between practice prior to 1930 and the present:

1. In Hardin's summary nearly two-thirds of the filters had perforated pipe laterals, with or without strainers; only six of the fifteen plants built recently have this type.

2. Nearly all filters twenty years ago were rated at 2 gpm. per sq.ft. That rate is still common, but much higher rates are often used, particularly at some of the larger plants.

3. Sand layers 30 in. thick were most common prior to 1930; few filters built today have more than 24 to 27 in. of sand.

4. Relatively coarse sand, in effective sizes up to 0.6 mm., is fairly common today, although in most plants the effective size still ranges between 0.45 and 0.55 mm. Anthracite coal has also been more widely used in recent years.

5. Whereas practically no plants had surface wash facilities twenty years ago, most plants built recently have included provision for surface wash in their equipment.

References

1. Standard Specifications for Filtering Material—5C-1950. Am. Water Works Assn., New York (1950); *see also* Jour. A.W.W.A., 41:289 (Mar. 1949).
2. BAYLIS, JOHN R. Experience With High-Rate Filtration. Jour. A.W.W.A., 42: 687 (July 1950).
3. HARDIN, EUGENE A. Design and Operation Data on Large Rapid Sand Filtration Plants in the United States and Canada. Jour. A.W.W.A., 24:1190 (Aug. 1932).

Relative Pipe Roughness

By Harry H. Chenoweth and Robert E. Leaver

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BECAUSE considerable progress has been made during the last few decades in fluid mechanics, it is advisable that flow formulas used in water works practice, and especially their applications and limitations, should be reexamined. Since the comprehensive comparison of formulas for pipe flow by Julian Hinds (1) was published, a thought-provoking article by C. W. Harris (2) on the same general subject, has appeared. Now, in this paper, the authors have applied some of Harris' concepts to other flow formulas. Their purpose is not to advocate particular formulas, but rather to stimulate interest in the subject and to show the versatility of a semirational or reasonable approach. The authors feel that a proper recognition of the distinction between partially turbulent flow and fully turbulent flow will result in a distrust of purely empirical formulas and their ultimate discard in favor of the rational type. At least, a better understanding of the limitations and range of application of the strictly empirical formulas will be achieved. A brief review of flow principles will show these new concepts in better perspective.

Fluids flow in one of three modes: fully turbulent flow, partially turbulent flow and nonturbulent flow.

Fully Turbulent Flow

At high velocities in smooth pipes and at moderate and high velocities in rough pipes, the roughness of the pipe walls is exposed to the full flowing stream and the head lost to friction may be found by the Darcy-Weisbach formula:

$$H = f \frac{LV^2}{D2g}$$

The velocity above which full turbulence occurs is given by Equation 4. This equation shows that a new iron pipe carrying water at 55°F. will be in full turbulence at velocities above 10.0 fps., and that an average cast-iron pipe belonging to the permanent city mains, will be in full turbulence above a velocity of 0.2 fps. The Darcy-Weisbach formula is rational, dimensionally correct and exact. The friction factor f depends on the relative pipe roughness; pipes of the same relative roughness (such as (A) and (B) in Fig. 1) have the same friction factor. Froude's law of similitude requires this constant f for geometrically similar pipes. Pipes of a given material will not ordinarily be geo-

* When solved for velocity, this formula is identical to the Chezy formula $V = C \sqrt{rs}$,

where $C = \sqrt{\frac{8g}{f}}$

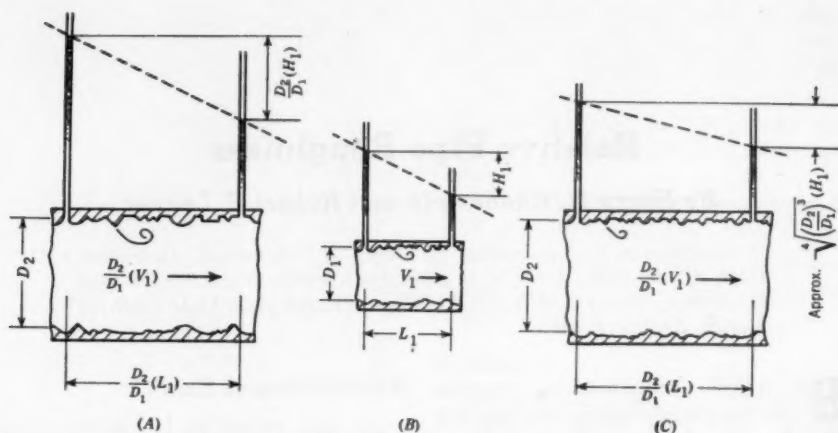


Fig. 1. Relative and Specific Roughness of Pipe

Pipes (A) and (B), in which the roughness dimensions are proportional to diameter, have the same relative roughness, and are kinematically similar. Pipes (B) and (C), however, with identical roughness dimensions but different diameters, have the same specific roughness but are not kinematically similar. The mathematics of (A) is:

$$f_2 = \frac{H_2 D_2}{L_2} \frac{2g}{V_2^2}$$

$$f_2 = \frac{\left[\frac{D_2}{D_1} (H_1) \right] D_2 2g}{\left[\frac{D_2}{D_1} (L_1) \right] \left[\sqrt{\frac{D_2}{D_1}} V_1 \right]^2} = f_1$$

For (B):

$$H_1 = f_1 \frac{L_1}{D_1} \frac{V_1^2}{2g}$$

$$f_1 = \frac{H_1 D_1}{L_1} \frac{2g}{V_1^2}$$

metrically similar, but they will have about the same surface texture (specific roughness) regardless of their size. A comparison of (B) and (C) in Fig. 1 reveals that the smaller pipes are not geometrically similar to the larger ones because the roughness dimensions have not changed in proportion with the diameter. This variable ratio of

roughness to diameter for various pipe sizes requires a variable f . Auxiliary equations are necessary to convert specific roughness to relative roughness (Eq. 5, 7, 9 and 10). One cannot correctly use a constant friction coefficient for all sizes of pipe of a given material. In fully turbulent flow, the head loss caused by friction

is independent of the viscosity (and, therefore, of the temperature of the water.

Partially Turbulent Flow

At medium velocities (V less than Eq. 4 but greater than $\frac{2300\nu}{D}$) the

for partially turbulent flow, the auxiliary equation for finding f must be a function of the viscous properties of the flow but not of the pipe roughness (see Eq. 1, 8 and 11). The applicability of these "partially turbulent" equations is wider for smooth pipes than for rough ones, as indicated by Fig. 2.

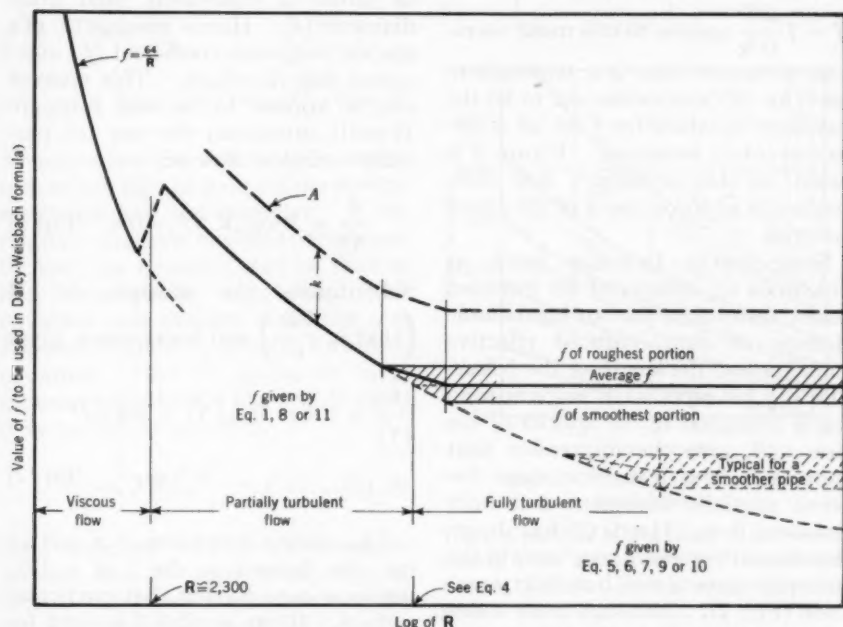


Fig. 2. Typical Friction Factor and Reynolds Number for Commercial Pipe

(A) represents the equivalent friction factor ($f + k$) if joints, bends and other localized losses or reduced effective diameters are included as part of the friction factor.

inner portion of the stream flows turbulently but a thin viscous sheath or laminar layer adjacent to the pipe wall literally masks its roughness. Roughness therefore, no longer affects the head loss but the viscosity (ν) does. If the Darcy-Weisbach formula is used

Nonturbulent Flow

At low velocities (V less than $\frac{2300\nu}{D}$), the flow will be nonturbulent. (Other terms used to describe this mode are viscous, laminar streamline,

sliding, and sinuous flow.) Although the characteristics of this type of flow are well understood, it occurs at velocities well below those commonly encountered in water works design.

Variation of f With R

Head loss due to friction varies with the square of the velocity only in fully turbulent flow. The formula

$$H = f \frac{LV^2}{D2g}$$

applies to this mode therefore, although there is a tendency to use it for all three modes and to let the auxiliary equation for f act as a correction when necessary. Figure 2 is based on this procedure, and summarizes in addition much of the above material.

Some recent formulas (such as Colebrook's), influenced by localized losses, distortions due to logarithmic plotting of data, reduced effective diameter and the length of the Nikuradse dip for pipes with uniform sand grains cemented to the interior of the pipe wall, give the impression that there is a long transition stage between partially turbulent and fully turbulent flow. Harris (2) has shown that several degrees of roughness in the same pipe cause a real, but short, transition (Fig. 2). Although most water works problems lie in the fully turbulent flow field, the ease with which data can be secured at low velocities has led to a disproportionate amount of these partially turbulent data being averaged into such empirical or experimental formulas as that of Hazen and Williams, which was intended for the water works field. Test data covering both ranges of flow are necessary if localized losses caused by joints, bends and other irregularities are to be separated from friction losses caused by surface roughness (Fig. 2).

The data thus secured may be applied with confidence to other diameters and velocities by means of the semirational formulas for f .

Auxiliary Equations for f

One of the disadvantages of the semirational formulas for f is the necessity of expressing pipe roughness in terms of equivalent sand grain diameter (s). Harris' concept (2) of a specific roughness coefficient (f_1) overcomes this drawback. This concept can be applied to the von Karman-Prandtl equations; the one for partially turbulent flow is:

$$\frac{1}{\sqrt{f}} = 2 \log_{10} R \sqrt{f} - 0.8 \quad (\text{Eq. 1})$$

Substituting the meaning of R (that is, $\frac{VD}{\mu}$) and transposing, gives

$$\begin{aligned} \frac{1}{2\sqrt{f}} + 0.4 &= \log_{10} \sqrt{f} - \log_{10} D \\ &= \log_{10} \frac{V}{\mu} \quad (\text{Eq. 2}) \end{aligned}$$

The specific roughness of a surface may be defined as the f of a 1-ft. diameter pipe having that particular surface. If the symbol f is used for relative roughness, then the symbol f_1 is logical for specific roughness. At the instant of change from partial turbulence to full turbulence, the value of f responds to either Reynolds number (R), or to specific roughness (f_1). When D equals 1 ft., f equals f_1 . Equation 2 becomes

$$\begin{aligned} \frac{1}{2\sqrt{f_1}} + 0.4 &= \log_{10} \sqrt{f_1} \\ &= \log_{10} \frac{V_c}{\mu} \quad (\text{Eq. 3}) \end{aligned}$$

hence:

$$\log_{10} V = \frac{1}{2\sqrt{f_1}} + 0.4 + \log_{10} \frac{v}{\sqrt{f_1}} \dots (\text{Eq. 4})$$

Equation 4 may be used to determine the velocity at which full turbulence will begin.

Substituting Eq. 3 in Eq. 2 gives:

$$\begin{aligned} \frac{1}{2\sqrt{f_1}} - \log_{10} \sqrt{f_1} \\ = \frac{1}{2\sqrt{f_1}} - \log_{10} \sqrt{f_1} + \log_{10} D \dots (\text{Eq. 5}) \end{aligned}$$

This equation gives the relative roughness of any pipe in terms of the specific roughness and the diameter. If the relative roughness has been determined by test, the equation may be used to find the specific roughness. This equation was derived from the von Karman-Prandtl partially turbulent equation. That it agrees in large measure with the von Karman-Prandtl fully turbulent equation,

$$\frac{1}{\sqrt{f}} = 2 \log_{10} \frac{D}{\epsilon} + 1.14 \dots (\text{Eq. 6})$$

(and therefore the Nikuradse experiments) can be seen from Fig. 3. Equation 6, when put in terms of the specific roughness coefficient f_1 , becomes

$$\frac{1}{\sqrt{f}} = \frac{1}{\sqrt{f_1}} + 2 \log_{10} D \dots (\text{Eq. 7})$$

A derivation starting from the Blasius (3) equation

$$f = \frac{0.316}{R^1} \dots (\text{Eq. 8})$$

yields

$$V_e = v \left(\frac{0.316}{f_1} \right)^4$$

for the velocity at which full turbu-

lence commences and

$$f = \frac{f_1}{D^1} \dots (\text{Eq. 9})$$

This equation for relative roughness has the same limitation as the original Blasius equation—that is, that f should be in the middle range of relative roughness for greatest accuracy.

Harris' velocity criterion (2) is $V_e = v \left(\frac{0.55}{f_1 - 0.0061} \right)^3$ and his equa-

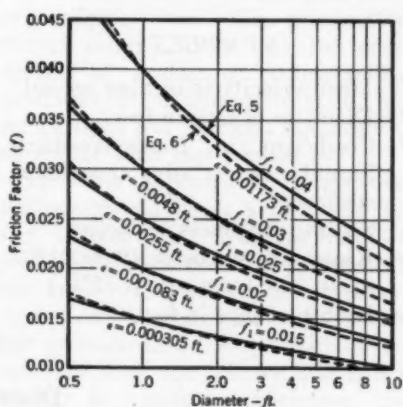


Fig. 3. Rough Pipe Formula Comparison

The comparison is of a rough pipe formula derived from a smooth pipe formula with the von Karman-Prandtl rough pipe formula.

tion for relative roughness is

$$f = 0.0061 + \frac{f_1 - 0.0061}{D^1} \dots (\text{Eq. 10})$$

derived from his partially turbulent equation

$$f = 0.0061 + \frac{0.55}{R^1} \dots (\text{Eq. 11})$$

The last two equations show substantial agreement with tests of fully turbulent (Eq. 10) and partially turbulent (Eq. 11) zones.

Conclusion

If a water works engineer is aware of the distinction between partially turbulent flow and fully turbulent flow, his experience will force skepticism of purely empirical formulas and a gradual acceptance of the rational type formulas. Furthermore, he will have a better understanding of the limitations and range of application of the strictly experimental.

SYMBOLS

- V —Mean velocity in feet per second
 D —Diameter of pipe in feet
 f —Coefficient in Darcy-Weisbach formula or relative roughness coefficient
 f_1 —Specific roughness coefficient
 ν —Kinematic viscosity (0.0001307 sq. ft./sec. for water at 55°F.)
 L —Length of pipe in feet

g —Acceleration of gravity (32.17 ft./sec./sec.)

H —Head loss in feet for a pipe of length L

C —Coefficient in Chezy formula

r —Hydraulic radius in feet

R —Reynolds number $\left(\frac{VD}{\nu}\right)$

s —Slope of hydraulic gradient

ϵ —A linear dimension representing height, form, and distribution of surface roughness expressed as equivalent sand grain diameter in feet.

References

1. HINDS, JULIAN. Comparison of Formulas for Pipe Flow. *Journal A. W. W. A.*, **38**:1226 (1946).
2. HARRIS, CHARLES W. An Engineering Concept of the Flow in Pipes. *Proc. A.S.C.E.*, **5**:555 (1949).
3. ROUSE, HUNTER. Modern Conceptions of the Mechanics of Fluid Turbulence. *Trans. A.S.C.E.*, **102**:463 (1937).

Discussion

Malcolm S. McIlroy

Prof. of Elec. Eng., Cornell Univ., Ithaca, N.Y.

The authors have continued a discussion of long standing between those who promote complete precision in statements of the relation between head loss and flow rate in a pipeline, and those whose work requires a relatively simple method of expressing this relation. In the writer's opinion, both views have their proper fields of application.

The engineer who designs an important pipeline, such as a hydroelectric station penstock or a trunk connection between a remote reservoir and a city

distribution system, is justified in using the very best thinking in fluid mechanics. Since the characteristics of one of these pipelines will probably not change as rapidly as will those of distribution mains, the achievement of high accuracy in computation by means of the rational relations discussed by the authors is certainly well worth while.

On the other hand, the water works engineer confronted with the problem of evaluating head losses and flows in a complex network faces a very different problem. His usual task is to choose a design for construction from the various possibilities that have promise. In conducting any analysis, he

must use certain approximations. Situations which affect these approximations include:

1. Takeoffs distributed at random.
2. Changes which age induces in the condition of the interior surfaces of pipelines.
3. The variations in service age of the pipelines in the network.
4. The normal fluctuations of loading of individual pipelines and entire network areas.
5. The need for skeletonizing the system and for lumping loads to reduce time spent in analysis.
6. Uncertainty about the condition of the interior of each pipeline in the system.

In view of these and other practical difficulties in evaluating friction factors throughout a network, the engineer who analyzes a distribution system appears justified in using a simple empirical formula. Over a fairly wide range of velocities, the Hazen-Williams formula, for example, appears satisfactory if the factors listed above make approximations unavoidable. No analysis of an existing system is reasonably trustworthy unless field checks have been made to determine average conditions of the pipelines. Once these conditions are found, whether they are expressed as a Hazen-Williams C or as a Darcy-Weisbach f makes very little difference for a considerable range of velocities above and below those present during the test. In general, for lower velocities, the Hazen-Williams formula gives a slightly higher head loss; for higher velocities, the Darcy-Weisbach relation gives a slightly higher head loss. Since there is randomness with time and place in flow

conditions in pipelines, these two effects tend to compensate in a network.

The distribution engineer usually employs a factor of safety to allow for expanding loads, and for depreciation of the pipelines. This safety factor tends to discount the need for extreme precision. The engineer does, however, need a good comparison between alternative construction plans, even though the absolute values of flows and head losses found for each plan may vary slightly from their presumably correct values. If he uses the same method of evaluating corresponding quantities in the alternative plans, his comparisons will have real significance, no matter what that method is.

The first approach to a network analysis should be as simple and direct as possible. Since friction factor is a function of velocity, one does not know what friction factor to assign to each pipeline until he has found the approximate velocity, which is determined from the solution and is not known in advance. Therefore, the engineer must either assume a friction factor or use an empirical formula with a smoothness coefficient based on average test results or on his own judgment. The empirical formula, with its constant coefficient and exponent, offers the easiest approach to a solution in a reasonable length of time. Furthermore, it is adaptable to the design of nonlinear resistors for use in the electrical-analogy method of analysis, which greatly speeds up solution. When a first solution is obtained from an empirical formula, the engineer may still alter it to account for the occasionally significant changes indicated by a rational formula, simply by changing the values of coefficients, and still reach his final solution with less total

effort than that required if the rational formula were used at the outset.

A study (1) has been made of the effect of random errors in assumptions of values of C or f for the individual pipelines in networks. This study shows a pronounced tendency for rather severe, randomly distributed, individual errors to cancel themselves in the determination of total head losses in a network. In fact, it appears that one can predict the probable error in total head loss as a function of the probable error in values of C or f , and that the value of this probable error in head loss is independent of the distances across which total head losses are measured in a network. The study indicates that high precision in the determination of values of C or f for individual pipelines is not necessary, but that the average condition found for a group of pipes gives sufficiently useful data for an analysis, subject to a known probable error in head loss at any point. In view of this study, there appears to be no strong reason to insist on the use of rigorous expressions in a solution which is not based on precise data.

The awareness of the distinction recommended by the authors between partially turbulent flow and fully turbulent flow is commendable. Because the velocity in a pipeline of a network is not known in advance of analysis, however, this distinction is likely to be useful only after a trial solution is made, indicating whether changes in original assumptions are needed. Then the corrections in the solution can be made by means of an empirical formula, with an accuracy well within the limits of the previously cited need for approximations.

It is the writer's belief that the authors have presented a good argument for rational methods of determining head loss in trunk transmission mains. For network-analysis work, however, the widely used Hazen-Williams formula is entirely adequate, if the same degree of judgment is applied to the results as is necessary in the use of the rational methods.

Reference

1. McILROY, MALCOLM S. Unpublished doctorate thesis. Massachusetts Inst. of Technology, Cambridge, Mass. (1946).

Use of Radio By Utilities

By George S. Moore

A paper presented on Nov. 13, 1950, at the North Carolina Section Meeting, Durham, N.C., by George S. Moore, Supt. of Utilities, Albemarle, N.C.

MOBILE radio systems for two-way utility communication are operated under rules established by the Federal Communications Commission. These very clearly define procedures for obtaining construction permits and licenses, and list in detail the methods of operation which must be followed. In addition to publishing its rules, the FCC maintains a staff of district engineers and inspectors who govern the licensing of operators and are responsible for seeing that the commission's regulations are enforced.

When considering the installation of a radio system therefore, it is wise to obtain a copy of Part 11 of the commission's rules, which are available from the Superintendent of Documents, Washington, D.C., at a cost of 10¢ per copy. The name and address of the nearest FCC district engineer is also helpful.

Before a radio system can be constructed, an FCC permit must be obtained and the frequency band of operation chosen. There are essentially two bands which are available for mobile use—the 30 to 50 mc. (megacycle) band and the 152 to 162 mc. band. Of the two, the lower frequency band has the advantage of greater coverage. Normally, one can expect a range of from 30–50 miles

on this band depending upon antenna height, power of transmitter and terrain to be covered. The disadvantage of the lower frequency, however, is that it is subject to so-called skip interference. During periods of severe skip interference, for example, a South American station may be picked up with a louder signal than the mobile units operating within their normal range.

The 152–162 mc. band, on the other hand, affords practically no skip interference and only reduced local interference from storms and other electrical disturbances. The disadvantage of this band is that it offers an operating range that is lower by approximately 10–15 miles than that of the lower band. Because of the annoying amount of skip interference, the FCC is attempting to place as many users as possible on the higher band. Anyone wishing to operate on one of the lower frequencies, therefore, must first convince the commission that the coverage offered by the higher frequency band would be inadequate.

When a band of operation has been selected, field tests can be conducted, under FCC license, to determine, among other things, what the number, location and power of the stations should be. To obtain a test license,

a notarized letter of application explaining the purpose of the tests must be filed in duplicate with the FCC in Washington. A temporary test-frequency may then be assigned.

In Part 11 of its rules, the FCC directs that licensees cooperate in the selection and use of frequencies to minimize interference. To facilitate such cooperation, national and regional committees have been set up to work out frequency patterns for each area which will produce a minimum of interference. Because the FCC will not accept any applications for permits without the regional committee's recommendation of the frequency requested, the committee secretary should be notified before any action is taken. The name and address of the committee secretary in each area was published in a recent issue of the *JOURNAL* (1). Information on the location of base stations, operating areas desired and the approximate number of mobile units contemplated should be supplied.

Unlike the application for a test permit, applications for construction permits must be made out on forms supplied by the FCC. A separate application must be submitted for each base station; one application, however, is sufficient to cover all mobile units. In preparing these applications, it is customary to include the maximum number of mobile units which might reasonably be expected to be put into operation during the next five-year period. Any number of mobile units up to those covered in the application can then be operated. If a station antenna is more than 150 ft. in height, or adjacent to a flying field or other special area, additional forms must be executed. The construction permit, when granted, allows a maximum of eight months

from time of issuance for work to be completed. If a longer period of time should be required, the construction permit must be extended or a new license applied for.

As soon as construction is completed station tests may be held upon notification of the FCC district engineer. At the conclusion of these tests, application for an operating license can be made to the commission. Approximately 60 days should be allotted for the application to be processed.

Licenses are issued for a term of from one to five years, the duration and expiration dates differing, so that all licenses granted under the new Power Radio Service will not expire at the same time.

All correspondence to FCC headquarters should be addressed to The Secretary, Federal Communications Commission, Washington 25, D.C.

Neither the electrical nor mechanical features of FM communication equipment nor the specifications and cost of such units will be discussed, since this information can be readily obtained from manufacturers. Such organizations as Motorola, Inc., Link Radio Corp., General Electric Co., Western Electric Co., Radio Corp. of America, Federal Telephone and Radio Corp. and others will not only mail technical specifications and descriptive literature on their most modern equipment, but, upon request, will send a representative to review individual requirements, plan a communication system, and submit cost figures, without any obligation or expense to the prospective customer. All of these radio manufacturers make transmitting and receiving apparatus particularly suited to utility requirements and applications.

Frequency-modulated or FM radio is recognized as the superior medium of sound broadcasting and the public is rapidly coming to appreciate the better reception it offers, its virtual freedom from static and other forms of interference, and its high-fidelity reproduction of sound. Amplitude-modulated (AM) radio, which has been in use since the introduction of the vacuum tube, is gradually being relegated to a minor role and will perhaps in time be entirely replaced.

In the AM system, the carrier wave is continuous and the voice or other signal curve is superimposed upon it. The effect of the signal, which employs a current of moderate radio frequency, is to contract or expand the amplitude in accordance with the intensity of the signal. In the FM process, it is the frequency rather than the strength of the carrier wave that is varied by the impressed signal. Carrier waves for FM transmissions are in the ultrashort wave region of the frequency spectrum.

Selection of the proper combination of equipment for any installation must be based on a consideration of the three basic communication systems. The type of system selected, whether one-way, two-way or three-way, will depend entirely upon the specific requirements of the utility.

Municipal and private water departments have been classified by the F.C.C. under the power utility group, which includes private and municipal electric power companies and cooperatives, manufactured gas and natural gas companies and steam companies. Committee 4, Panel 13, of the Radio Technical Planning Board, now known as the National Committee for Utilities Radio, comprising representatives of

the various utilities mentioned, has for a number of years aided the F.C.C. in the postwar planning of frequency allocations and in setting up standards for the radio service.

Through the efforts and sponsorship of the National Committee for Utilities Radio, ten regional radio groups have been formed. A representative of A.W.W.A. has been selected in each of these groups to act as a spokesman for the water works industry in the area and also to provide liaison between the regional group and the water works sections.

Radio communication offers the only rapid, practical, and safe means of maintaining contact with inspection and repair crews in restoring facilities and service, and in preserving life and property in emergencies. From the standpoint of improving public relations and increasing service to the public, the opportunities which radio offers are unsurpassed.

The radio communication system used by utilities in Albemarle, N.C., is operated in conjunction with the Police Dept. and until recently all emergency calls transmitted to mobile units had to be telephoned to the police first and then transmitted by the department's operator. The Utilities Dept., however, has recently installed a transmitting and receiving station (or remote station) through which messages can be sent directly. Two mobile units have been installed on trucks used by key men in the operating and maintenance division. These units are of the two-way type, making it possible for operators to both receive and transmit messages. The main transmitting station has a capacity of 45 w., operating on a frequency of 153.13 mc. The mobile units have

capacities of 30 w. and operate at the same frequency.

The speed which such a system makes possible is illustrated by the following incident: at 3:15 one morning a message was received from the Superintendent of Plants advising the Utilities Dept. that an excessive amount of water was being used, indicating the possibility of a serious line break. The foreman of the repair crew as well as the men in the mobile unit trucks were instructed to report immediately to the police broadcasting station. When the men were assembled, the two mobile unit trucks and two mobile unit police cars were dispatched to search for signs of a large leak. It was only a short time before one of the cars radioed

that there was evidence of a leak in a remote section of town.

While the men were scouting for the leak, the foreman of the repair crew waited at the radio station. Immediately upon being advised of the location of the leak, he proceeded to the section where it had been found and, by isolating the broken line, stopped the flow of water. The entire procedure required less than 45 minutes. Undoubtedly it would have taken very much longer to accomplish the same work with any other method of transmitting messages.

Reference

1. HECHMER, CARL A. ET AL. Use of Radio by Water Departments. *Jour. A.W.W.A.*, 41:891 (Oct. 1949).



Fibre Gaskets for Meter Couplings

By M. B. Cunningham

*A contribution to the Journal by M. B. Cunningham, Supt. & Engr.,
Water Dept., Oklahoma City, Okla.*

IN 1920 a water waste survey was conducted at Oklahoma City, Okla., for the purpose of placing the distribution system in good operating condition. Only 46 per cent of the water pumped had been sold in the previous year. As a result of the survey, the percentage of water accounted for was increased to 95 after the repair of distribution system leaks and the reconditioning of water meters. As a consequence of this program, fibre gaskets were adopted for use in the water meter couplings.

In 1920 the department had 11,500 meters in service. Field maintenance, including the replacement of dead meters and the repair of leaks in the meter connections, required four servicemen. Today there are 58,000 meters in service, and two field men take care of the maintenance. A good many factors enter into this reduction in maintenance time and cost, such as the style of meter setting, which permits easy installation or removal, and the fact that meters now manufactured have greater operating efficiency and longer life than formerly.

Copper service pipe is used, the meter being set on a 6-in. riser with an angle curb stop and outlet connection. This setting is employed for $\frac{3}{4}$ -, $\frac{1}{2}$ - and 1-in. meters. It was found that leather gaskets could not be used, since the meter must be held in a rigid, upright position. The leather gasket

would permit the meter to tilt under ordinary vibration. A number of leaks were discovered, which resulted in expensive maintenance and, even more serious, consumer complaints. Tests were therefore made on all known gasket materials, and fibre gaskets turned out to be ideal, making a permanent, watertight, rigid joint, requiring no maintenance. Such gaskets have been used in meter connections since 1921. For 27 years no difficulty whatsoever was experienced with this material, but, in 1948, trouble arose in one lot of 10,000 gaskets after three years in service. The long period of previously uninterrupted service naturally led to the conclusion that the manufacturer had supplied gaskets which were not suited to the utility's use.

Leakage in the fibre gaskets in question had resulted from a porous condition that had developed in the material. Despite extended correspondence with the department's usual suppliers, fibre gasket specifications written for this particular application could not be located. At the department's request, the Oklahoma Testing Laboratory of Oklahoma City, a commercial organization, undertook the development of specifications on this material.

Fibre Tests

In the meantime the Ford Meter Box Co. had referred the department

to the Continental Diamond Fibre Co. of Newark, Del. This company very generously analyzed the fibre gaskets sent to it and not only furnished a technical discussion of the problem, but gave suggestions on the writing of the specifications and has since approved those now used by the department in the purchase of all fibre gaskets.

Although it was first believed that the failure of the one shipment of fibre gaskets might possibly have been associated with the war situation, it later became obvious that the lack of proper procurement specifications was the cause. It was evident that the manufacturer had simply supplied gaskets made with various types of fibre, without full knowledge of the application for which they were intended. Comment from the Continental Diamond Fibre Co. bears out the opinion, based on Oklahoma City's experience, that gaskets made of vulcanized fibre of the proper type are entirely satisfactory. A review of the chemical analyses of the potable water supplies would indicate that they contain nothing which should contribute to the degradation of such fibre over a reasonable span of useful life.

The company was very helpful in making a careful series of tests on fibre gaskets provided by the water department. These samples had been obtained from various sources without specifications for use in water meter couplings. A good many were shown to be unsuited for this use. A large number of gaskets contained flexing agents, such as diethylene glycol or glycerine, which cannot be tolerated in this material, since they will dissolve and cause a porous condition that would result in leakage. This fact accounts for the gasket failure in 1948. Other gaskets showed some tendency toward ply separation, sometimes due to a low specific gravity, which may also contribute to the softness of the material.

It is fairly obvious, not only from Oklahoma City's experiences but from those of many other utilities, that fibre gaskets are entirely satisfactory and desirable for use in water meter couplings when this material is purchased under appropriate specifications. It is believed that the specifications adopted by Oklahoma City (*see Appendix*) will prevent any further trouble with fibre gaskets.

APPENDIX

Oklahoma City Water Department Specifications for Fibre Gaskets

General. Fibre gaskets shall be furnished in accordance with the requirements as set forth in these specifications.

Use. Fibre gaskets desired are to be used to form a watertight connection between water meter coupling and spud, corporation stops and other related water works brass goods. Water pressure 150 psi., temperature of the water from 33°F. to 85°F.

Material. The fibre used in the manufacture of these gaskets shall be commercial hard-rag-base fibre made from zinc

chloride cellulose fibre washed and pressed to sheet form. Under no conditions will a plasticized fibre be accepted. The general characteristics of this fibre shall be in conformance with a commercial grade of fibre as covered by the American Society for Testing Materials Designation D710, latest revision.

Color. The color shall be gray, unless otherwise specified.

Specific gravity. The specific gravity of the fibre as determined in accordance with procedure outlined in A.S.T.M.

Method D619, latest revision, shall range between 1.25 and 1.35. (D792-48T.)

Zinc chloride content. The zinc chloride content as determined in accordance with A.S.T.M. Method D619, latest revision, shall not exceed 0.10 per cent.

Ply adhesion. The fibre shall be very well laminated and show no tendency toward easy ply separation when submerged in water.

Finish. Fibre used for this application shall have a reasonably smooth surface, and under no circumstances must it have

side as good commercial practice will permit.

Flexing agents. The fibre shall contain no plasticizers or flexing agents, such as diethylene glycol or glycerine, which might show a tendency to dissolve out in contact with water and cause disintegration of the gasket.

Freedom from defects. Fibre gaskets shall be clean, hard and straight, with smooth surfaces. They shall be free from all cracks, seams, blisters, flaws and other defects.

TABLE 1
Sizes and Tolerances

Item	Meter Size—in.			Tolerance in.
	$\frac{1}{4}$	$\frac{1}{2} \times \frac{1}{2}$	1	
Meter spud—iron pipe thread	$\frac{3}{4}$	1	$1\frac{1}{4}$	
Inside hole diameter	$\frac{9}{16}$	$\frac{3}{4}$	$1\frac{1}{32}$	± 0.010
Outside diameter	$\frac{13}{16}$	$1\frac{1}{4}$	$1\frac{1}{2}$	± 0.010
Thickness	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{3}{32}$	± 0.005

a hard, calendered finish which would tend to reduce its softness for proper sealing, but rather it should be preferably uncalendered, or have just a very slight amount of calendering.

Fabrication. Fibre gaskets of the sizes as prescribed shall be punched with a shaved edge inside and outside, and the hole must be as concentric with the out-

Sizes and tolerances. Sizes and tolerances allowable shall be: [as shown in Table 1].

Test Report. Manufacturer supplying fibre gaskets shall submit a certified test report showing analysis of fibre and measurements as stipulated in body of these specifications and in conformity thereto.

Report of the Audit of Association Funds

For the Year Ending December 31, 1950

To the Members of the American Water Works Association:

The By-Laws require that the Secretary shall have an annual audit made of the books of the Association.

The records for 1949 have been examined by the staff of Louis D. Blum & Co. The complete record of that examination follows.

Reference may be made to past audits which appeared in the JOURNAL as follows: pp. 520-25, March 1938; pp. 570-74, March 1939; pp. 516-20, March 1940; pp. 774-78, April 1941; pp. 426-30, March 1942; pp. 338-42, March 1943; pp. 359-63, March 1944; pp. 317-21, March 1945; pp. 386-90, March 1946; pp. 273-78, March 1947; pp. 345-50, March 1948; pp. 257-61, March 1949; and pp. 287-91, March 1950.

Respectfully submitted,

HARRY E. JORDAN
Secretary

January 25, 1951

TO THE AMERICAN WATER WORKS ASSOCIATION:

We have examined the balance sheet of the American Water Works Association as of December 31, 1950, and the related statements of income and surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet as of December 31, 1950, and the related statements of income and surplus present fairly the financial position of the American Water Works Association at that date and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(Signed)

LOUIS D. BLUM & Co.
Certified Public Accountants

EXHIBIT A—BALANCE SHEET

DECEMBER 31, 1950

Assets

<i>Cash in Banks and on Hand</i>		\$ 35,779.19*
<i>Accounts Receivable:</i>		
Advertising in Journal	\$7,351.50	
Advertising in 1950 Membership Directory	3,448.00	
Reprints	391.26	
Manual—Water Quality and Treatment	568.40	
Sundry specifications	116.23	
Other	151.93	12,027.32
<i>Membership Dues</i>		489.00
<i>Accrued Interest on Bonds</i>		527.54
<i>Inventories:</i>		
Paper stock	4,319.64	
Type metal	1,338.65	
Cumulative Index (201 copies)	241.20	
Quest for Pure Water—Baker	1,658.57	
Survival and Retirement Book	1,390.51	
Manual—Water Quality and Treatment	6,672.00	
Sundry specifications	1,702.61	
Back issues—Journals—Vol. 1 to 42, inclusive (36,737 copies)	—†	
Back issues—Proceedings, 1881–1913, inclusive (257 copies)	—†	17,323.18
<i>Office Equipment (less depreciation)</i>		7,626.51
<i>Investments at Cost (Schedule 1)</i>		113,604.88
<i>Deferred Expenses</i>		1,422.51
<i>Deposit—Airlines</i>		425.00
TOTAL ASSETS		\$189,225.13

Liabilities and Surplus

<i>Accounts Payable</i>	\$ 230.03
<i>Membership Dues—Advance Payments</i>	35,814.04
<i>Unearned Subscriptions to Journal</i>	2,924.88
<i>Payable to American Water Works Association Pension System</i>	30,000.00‡
<i>Reserve for Award Fund (McCord)</i>	53.02
<i>Surplus, per Exhibit C</i>	120,203.16
TOTAL LIABILITIES AND SURPLUS	\$189,225.13

* Canadian funds in the Bank of Montreal as at December 31, 1950, amounted to \$2,615.03, which, if converted into American currency at that date would have resulted in a loss of approximately \$147.10. Had this loss been recorded, the cash in banks and the surplus would have been decreased accordingly.

† Back issues of Journals and Proceedings are inventoried but no money values are assigned to them for balance sheet purposes inasmuch as the entire costs were charged off during the year of publication.

‡ Secured by assignment of the income of United States Savings Bonds, Series G, and maturity redemption value of such bonds in the amount of \$30,000.

EXHIBIT A, SCHEDULE 1—INVESTMENTS

DECEMBER 31, 1950

Description	Interest Rate %	Principal Amount	Cost	Quoted Market or Redemption Value Dec. 31, 1950
<i>Foreign Securities (see notes):</i>				
Province of British Columbia	4½	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00*
Province of Ontario	4	1,000.00	732.50	1,126.25*
Canadian Victory Bonds	3	6,000.00	5,647.75	5,752.50†
Canadian Victory Bonds	3	2,000.00	2,000.00	1,887.50†
Hydro Electric Power Commission of Ontario	2½	5,000.00	5,075.00	4,443.75†
Province of Ontario	3	2,000.00	2,022.50	1,865.00†
Hydro Electric Power Commission of Ontario	3	2,000.00	2,020.00	1,865.00†
<i>United States Securities:</i>				
U.S. Savings Bonds:				
Series G	2½	10,000.00	10,000.00	9,730.00
Series G	2½	10,000.00	10,000.00	9,550.00
Series G	2½	10,000.00	10,000.00	9,470.00
Series G	2½	2,000.00	2,000.00	1,934.00
Series G	2½	5,000.00	5,000.00	4,820.00
Series G	2½	2,000.00	2,000.00	1,910.00
Series G	2½	10,000.00	10,000.00	9,520.00
Series G	2½	3,000.00	3,000.00	2,847.00
Series G	2½	2,000.00	2,000.00	1,894.00
Series G	2½	10,000.00	10,000.00	9,470.00
Series G	2½	5,000.00	5,000.00	4,740.00
Series G	2½	2,000.00	2,000.00	1,896.00
Series G	2½	7,500.00	7,500.00	7,215.00
Series G	2½	2,500.00	2,500.00	2,500.00#
U.S.A. Treasury Savings Note, Series D	1.4	5,000.00	5,000.00	5,116.00†
U.S.A. Treasury Notes, Series A	1½	9,000.00	8,991.13	8,986.64
Excess of redemption value of U.S. Treasury Savings Note, Series D, over issue price			116.00	
			\$113,604.88	\$109,538.64

* These securities are payable in United States funds.

† These securities are payable in Canadian funds. Market value represents value in New York in United States funds.

‡ These amounts represent redemption value at Dec. 31, 1950.

§ Redemption value and income from these securities assigned to American Water Works Association Pension System.

|| Yield, if held to maturity.

This bond is not redeemable until Feb. 1, 1951; it is valued herein at cost.

EXHIBIT B—STATEMENT OF INCOME AND EXPENSES

FOR THE YEAR ENDED DECEMBER 31, 1950

Operating Income:

Annual dues	\$83,836.60
Advertising	71,526.00
1950 Membership Directory	3,700.25

OPERATING INCOME (carried forward) \$159,062.85

OPERATING INCOME (brought forward)		\$159,062.85
Subscriptions to Journal	5,853.59	
Convention registration fees	14,422.50	
Convention—other events	4,109.66	
Water and Sewage Works Manufacturers' Assn.	7,500.00	
Interest on investments	2,090.02	
John M. Goodell prize	75.00	
Miscellaneous interest income	7.08	
TOTAL OPERATING INCOME		\$193,120.70
<i>Publication Income:</i>		
Manual of Water Works Accounting	218.82	
Reprints	4,332.70	
Cumulative Index	79.50	
Membership Certificates	49.70	
Proceedings and Journals	823.70	
Quest for Pure Water—Baker	831.50	
Survival and Retirement Book	123.00	
Manual—Water Quality and Treatment	926.80	
Sundry specifications	4,812.53	
One-half of profit from sales of Standard Methods ..	2,953.85	
TOTAL PUBLICATION INCOME		15,152.10
TOTAL INCOME		\$208,272.80
<i>Operating Expenses:</i>		
<i>Directors' and Executive Committee Meetings:</i>		
Travel expense	\$ 5,673.60	
Stenographic expense	483.40	6,157.00
<i>Administrative Expenses:</i>		
Rent	5,070.00	
Office supplies and services	9,608.08	
Membership promotion	815.67	
Pension—Secretary Emeritus	2,500.00	
Contribution to pension system	3,550.12	
Legal and accounting expenses	1,660.77	
General and special travel	1,052.34	
Federal activities	889.49	25,146.47
Administrative Salaries		54,816.82
Committee Expense		985.00
<i>Division and Section Expenses:</i>		
Section—membership allotment	15,220.80	
Section—official travel	4,567.42	
Section—general expense	342.31	20,130.53
<i>Journal:</i>		
Printing	35,262.53	
Production	3,727.41	
Paper	9,687.55	
Abstractors	181.09	
1950 Membership Directory	8,204.33	57,062.91
OPERATING EXPENSES (carried forward)		\$164,298.73

OPERATING EXPENSES (brought forward).....	\$164,298.73	
<i>Convention:</i>		
General.....	\$ 6,703.34	
Entertainment.....	10,154.29	
Management Committee.....	105.01	
Publicity.....	692.94	17,655.58
<i>Membership Dues in Other Associations.....</i>		542.50
<i>John M. Goodell Prize.....</i>		75.00
<i>Depreciation of Office Equipment.....</i>		995.05
<i>Miscellaneous Expenses.....</i>		194.02
TOTAL OPERATING EXPENSES.....		\$183,760.88
<i>Cost of Publications Sold:</i>		
Manual of Water Works Accounting.....	\$ 86.05	
Reprints.....	3,401.31	
Cumulative Index.....	44.40	
Membership Certificates.....	48.35	
Proceedings and Journals.....	80.12	
Quest for Pure Water—Baker.....	416.88	
Survival and Retirement Book.....	81.17	
Manual—Water Quality and Treatment.....	1,083.66	
Sundry specifications.....	2,782.17	8,024.11
<i>Development Activities:</i>		
Public Relations.....	6,029.48	
Research—Jute Packing.....	1,657.00	
Research—Compensation.....	139.09	7,825.57
TOTAL EXPENSES.....		199,610.56
<i>Net Income for the Year (Transferred to Exhibit C).....</i>		\$ 8,662.24
EXHIBIT C—SURPLUS FOR THE YEAR ENDED DECEMBER 31, 1950		
<i>Balance, January 1, 1950.....</i>		\$111,540.92
<i>Add: Net income for the year, per Exhibit B.....</i>		8,662.24
<i>Balance, December 31, 1950, per Exhibit A.....</i>		\$120,203.16

American Water Works Association Pension System

A change in the federal Social Security law during 1950 made coverage under that act available to employees of nonprofit organizations for the first time. Since adoption of such coverage required assent by both employer and employees, the Board of Directors offered coverage and issued an information bulletin which explained the benefits of Social Security and its integration with the Pension System. In a poll to determine action upon the offer, however, a majority of the employees voted against Social Security coverage.

The complete text of the pension plan was published in the March 1949 Journal.

Pension System Financial Statements

BALANCE SHEET—DECEMBER 31, 1950

<i>Assets</i>		<i>Liabilities and Reserve</i>	
Cash in bank.....	\$10,231.46	Liability for refund of employees' contributions plus earned interest.....	\$ 1,986.07
Accrued bond interest.....	208.34	Reserve for future benefits:	
Investments:		Reserve January 1, 1950.....	53,889.25
U.S. Savings Bonds, Series G (at cost).....	20,000.00*	Addition for 1950.....	4,564.44
Due from Association.....	30,000.00†		
TOTAL ASSETS.....	\$60,439.80	TOTAL LIABILITIES AND RESERVE.....	\$60,439.80

* Redemption value \$19,570 at December 31, 1950.

† Secured by assignment of the income of U. S. Savings Bonds, Series G, and maturity redemption value of such bonds in the amount of \$30,000.

RECEIPTS AND DISBURSEMENTS FOR THE YEAR 1950

	Cash	Reserve for Future Benefits	Liability for Refund of Employee Contributions
<i>Receipts:</i>			
Association contributions.....	\$ 3,550.12	\$ 3,550.12	
Employee contributions.....	1,100.31		\$1,100.31
Interest on bonds.....	1,125.00	1,125.00	
	5,775.43	4,675.12	1,100.31
<i>Disbursements:</i>			
Refund of contributions plus interest.....	153.91		153.91
Audit and legal expense.....	200.00	200.00	
Office expenses.....	6.00	6.00	
	359.91	206.00	153.91
Excess of cash receipts over disbursements.....	5,415.52	4,469.12	946.40
<i>Adjustments for noncash items:</i>			
Interest credited to employees' accounts.....		(29.64)	29.64
Interest accrued on bonds Jan. 1, 1950.....		(83.34)*	
Interest accrued on bonds Dec. 31, 1950.....		208.34 †	
		95.36	29.64
Additions to accounts for year.....	5,415.52	4,564.48	976.04
Balance Jan. 1, 1950.....	4,815.94	53,889.25	1,010.03
Balance Dec. 31, 1950.....	\$10,231.46	\$58,453.73	\$1,986.07

* Accrued interest receivable per balance sheet 12/31/49.

† Accrued interest receivable per balance sheet 12/31/50.

() Indicates deductions.

A.W.W.A. Membership Growth*Membership Statement—1950*

	Active	Corporate	Municipal Service Subscribers	Associate	Honorary	Junior	Affiliate	Total
Total members, Jan. 1, 1950.....	6521	668	96	299	32	43	50	7710
Change in membership grade.....	4				3	7		
	6525	668	96	299	35	36	50	7710
<i>Gains:</i>								
New in 1950.....	703	74	19	31		18	6	851
Reinstated in 1950.....	51	3		4				58
	7279	745	115	334	35	54	56	8619
<i>Losses:</i>								
Resignations and deaths.....	117	3	1	3	3		1	128
Dropped for nonpayment.....	376	23	3	7		6	6	421
Total members, Dec. 31, 1950.....	6786	719	111	324	32	48	49	8070
Total members, Jan. 1, 1950.....	6521	668	96	299	32	43	50	7710
Net Gain in 1950.....	265	51	5	25		5	-1	360

Comparative Statement—Gains and Losses—20-Year Period

Year	New	Reinstated	Resignations and Deaths	Suspended for Nonpayment of Dues	Gain or Loss	Total Members at End of Year
1930	501	39	122	134	+285	2831
1931	203	22	123	216	-114	2717
1932	117	22	169	297	-327	2390
1933	168	56	159	234	-169	2221
1934	271	66	86	122	+129	2350
1935	565	42	85	190	+332	2682
1936	311	53	104	218	+42	2724
1937	515	86	122	139	+340	3064
1938	520	59	144	140	+295	3359
1939	578	64	112	179	+351	3710
1940	514	58	113	212	+247	3957
1941	480	92	116	236	+220	4177
1942	570	59	132	233	+264	4441
1943	769	88	130	198	+529	4970
1944	734	92	140	171	+515	5485
1945	543	56	111	235	+253	5738
1946	816	79	168	324	+403	6141
1947	933	74	143	349	+515	6656
1948	847	81	207	347	+374	7030
1949	1083	75	196	323	+639	7669
1950	851	58	128	421	+360	8070

Report of the Committee on Water Works Practice

For the Year Ending December 31, 1950

A report of the activities of the Committee on Water Works Practice for the year ending Dec. 31, 1950, submitted to the A.W.W.A. Board of Directors Jan. 15, 1950, by Louis R. Howson, Chairman.

THIS report covers, for the calendar year 1950, the technical committee activities of the American Water Works Assn. conducted under the guidance of the Committee on Water Works Practice.

E4A—Deep Wells. This committee is now preparing a document describing recommended procedure for sealing abandoned water wells.

E5-1—Specifications and Tests for Water Purification Chemicals. Specifications for the following materials have been completed and published:

Subject	Published
Sodium Chloride	Mar. 1950
Ammonium Sulfate	Nov. 1950
Bauxite	July 1950
Ferrous Sulfate	Oct. 1950
Trisodium Phosphate	June 1950
Activated Carbon	Feb. 1951
Sodium Fluoride	Sept. 1950

The following are in the hands of referees for final editing:

Caustic Soda
Aluminum Sulfate
Lime (Quicklime and Hydrated Lime)
Soda Ash

E5-4—Practical Loading Capacities of Water Treatment Plants. A final report on sludge contact settling basins has been distributed to the Committee on Water Works Practice and to the Board.

E5-6—Specifications for Filtering Material. Certain questions have arisen which make it desirable to add a foreword to the existing specifications document which will clearly state the responsibility of the purchaser for full inspection of material before purchase.

E5-7—Open-Air Reservoirs. Chairman Howard has so far been unable to develop a report upon which general agreement could be obtained. A final statement for the committee is now in preparation.

E5-8—Disposal of Wastes From Water Purification and Softening Plants. A report on disposal of wastes from simple purification plants is in preparation. A supplemental report on disposal of wastes from lime-softening plants is also under way. Both are expected to be completed at the time of the Miami Conference in April.

E5-9—Standard Methods for the Examination of Water and Sewage. Chairman R. L. Derby has organized 14 subcommittees to develop material for the 10th edition of *Standard Methods*. The work assigned to these subcommittees covers all chemical determinations of water quality.

E5-10—Fluoridation Materials and Methods. This special task group has been set up to correlate information concerning: [1] materials to be used in the fluoridation of public water sup-

plies; [2] methods and equipment used in applying fluorides; and, [3] procedures designed to safeguard the health of employees handling fluoridation chemicals.

E6A—Water Hammer. This is a reconstituted committee. A special statement concerning the work of the committee will be presented by the chairman at the Miami conference.

E7A—Steel Pipe. A series of revisions of existing specifications were approved early in 1950, and published in the March 1950 JOURNAL.

The Steel Pipe Committee recommended that Tentative Specifications 7A.2—T for Lock Bar Pipe (1940) be withdrawn. [The Board of Directors accepted the recommendation and the Specifications for Lock Bar Pipe (7A.2—T) have been withdrawn as an official A.W.W.A. document.] The Board also reviewed questions affecting the Specifications for Cement-Mortar Lining of Steel Pipe—7A.7. The following recommendation by H. A. Price, Co-chairman of the Steel Pipe Committee, was considered:

Suggest board eliminate Sec. 7.4 (Field Application of Cement Mortar Lining) together with all reference to cement-mortar linings applied to steel pipe in place.

The Board, acting upon this recommendation, ruled:

That Sec. 7.4 of the 7A.7 specifications covering cement lining of steel pipe in place be withdrawn not later than June 30, 1951; and, that Committee E7A be directed to submit an acceptable alternate specification as early as possible, but not later than Apr. 1, 1951.

E7B—Reinforced Concrete Pipe. Specifications for "Reinforced Concrete Water Pipe—Non-Steel Cylinder Type, Not Prestressed" have been developed

and submitted to the committee. They will be published as soon as they are approved by the Board.

E7D—Laying Cast-Iron Pipe. "Tentative Standard Specifications for Laying Cast-Iron Water Mains—7D.1—T—1949" was published in the December 1949 JOURNAL. No formal suggestions concerning revision of the material have yet been filed. There seems to be no compelling reason for advancing the document to *Standard* status at this time.

"A Procedure for Disinfecting Water Mains—7D.2—1948" is now being reexamined by the committee operating under the chairmanship of M. P. Crabbill. Quaternary ammonium compounds have been used with some success as cleansing and disinfecting agents in the treatment of water mains. The wide commercial availability of the materials can make their acceptance by the committee of considerable value to the water works industry.

7C.1—1908—Standard Specifications for Cast-Iron Special Castings. The Board accepted the recommendation that specifications 7C.1—1908 be revised to cover fittings and specials. The tabulation of weights has been redone and the text, as well as the tabulation, will be submitted to members of the Board for final approval. The Board also agreed that the portions of the 1908 specifications which cover pipe be reprinted for reference as an historical document, as considerable tonnage of pipe produced under this specification remains in service.

E7E—Asbestos-Cement Pipe. The second draft of these specifications was sent to all committee members on Nov. 7, 1950. A consensus has not yet been recorded by the chairman.

E7F-1—Valves. Following the distribution of a revised text of these

specifications, a special committee of valve manufacturers filed a completely rearranged and revised document. Points of difference have not yet been resolved; the text, therefore, is not ready to submit to the Board.

E7F-2—Sluice Gates. This document was accepted as tentative in 1941 and has not yet been advanced to standard. Sluice gates are elements in water works construction which are often ordered to fit special conditions. For this reason, the chairman of the committee has held that the document should remain tentative.

E7F-3—Fire Hydrants. The text of the 1939 standard has been revised in accordance with the committee's suggestions, rearranged and distributed to committee members. A consensus has not yet developed.

E7S—Service Line Materials. The chairman of the committee has prepared a questionnaire on methods of service line installation which is to be mailed to all cities with a population of more than 25,000. It is hoped that the results of the survey can be analyzed in time for the Miami meeting.

Joint Committee with Other Organizations

Field Welding of Steel Water Pipe Joints. This document was approved as tentative in January 1946 and published in the March 1946 issue of the JOURNAL. Subsequent revisions were approved and published in the March 1950 JOURNAL. Upon the recommendation of the joint committee, the Board of Directors approved the advancement of the document to "Standard" status on Nov. 27, 1950.

Steel Standpipes and Elevated Tanks. Revision of structural details described in the specification are now in progress; the painting section will

also be revised so that the material relating to "first-time-painted" tanks (in 7H.1-1948) and "repainted" tanks (in 7H.2-T-1949) will agree.

Standard Dimensions of Flanges for Steel Water Pipe. The status of this project at midsummer 1950 was reported in the October 1950 JOURNAL. No further information has been received.

Correlating Committee on Cathodic Protection. The fourth and last document in this series covering "Technical Practices in Cathodic Protection" is now before the committee for approval. With the release of this bulletin, the work that the committee had planned will be completed.

Committees Operating Under A.S.A. Procedure

A.S.A. Committee A21 is now engaged in the following activities:

Revision of *A21.1-1939*—American Recommended Practice Manual for the Computation of Strength and Thickness of Cast-Iron Pipe.

Revision of *A21.2-1939*—American Standard Specifications for Cast-Iron Pit-Cast Pipe for Water or Other Liquids.

Revision of *A21.3*—Pit-Cast Pipe for Gas.

Revision of *A21.4-1939*—American Standard Specifications for Cement-Mortar Lining for Cast-Iron Pipe and Fittings.

Revision of *A21.5*—Tar Dip Coating.

Revision of *A21.6*—Pipe Centrifugally Cast in Metal Molds for Water.

Revision of *A21.7*—Pipe Centrifugally Cast in Metal Molds for Gas.

Revision of *A21.8*—Pipe Centrifugally Cast in Sand-Lined Molds for Water.

Revision of A21.9—Pipe Centrifugally Cast in Sand-Lined Molds for Gas.

A21.10—Short Body Cast-Iron Fittings, 3 in. to 12 in., for 250 psi. Water Pressure Plus Water Hammer.

Exception was taken by A.W.W.A. to the omission of specific requirements for fittings in the A21.10 document submitted to the sponsor bodies. After consideration of the matter, the Board ruled:

That the Secretary be instructed to advise the Chairman of A.S.A. Committee A21 that the A.W.W.A. withholds its approval of Specifications A21.10 until a clause covering the coating of specials is included, reading substantially as follows: "Any particular lining or coating which is to be applied to the fittings shall be specified in the agreement made at the time of purchase. In the absence of such specification, coating shall be in accordance with the current practice of the manufacturer. Separate specifications for cement-mortar lining have been provided in connection with these specifications for fittings."

A21.11—Specifications for Mechanical Joint for Cast-Iron Pipe and Fittings. Subcommittee work has been completed and the proposed specifications are being circulated within the committee. The A.W.W.A. has filed suggestions for clarification.

Specifications for Deep Well Vertical Pumps. This A.S.A. committee, operating under A.W.W.A. sponsorship, is preparing a draft of specifications for deep well vertical pumps and their testing. The committee is giving particular consideration to certain test procedures being developed under A.S.M.E. direction.

A.S.C.E., A.B.A. Committee on Rates and Rate Structures in Water and Sewage Works. D. L. Erickson, who acts as liaison representative for A.W.W.A., maintains close contact with Chairman Ayres of the A.W.W.A. rate committee. All prior reports of the A.W.W.A. committee have been published and the committee chairman hopes to be able to present a brief outline of basic considerations in establishing water rates at the Miami Conference.

A.W.W.A. is represented on the following A.S.A. Committees which have work in progress, but which have taken no definite action during 1950:

- B2.1—Pipe Threads
- B16—Pipe Flanges & Fittings
- B31—Code for Pressure Piping
- C1—National Electrical Code
- Z10—Letter Symbols & Abbreviations
- Z23—Sieves for Testing Purposes
- Z32—Graphical Symbols for Drawings
- Z59—Permeability.

Report of the Committee on Water Works Administration

For the Year Ending December 31, 1950

A report of the activities of the Committee on Water Works for the year ending December 31, 1950, submitted to the A.W.W.A. Board of Directors on Jan. 15, 1950, by W. R. LaDue, Chairman.

THE Committee on Water Works Administration came into being at the Atlantic City Conference of 1948. The background of its organization was fully set forth in the 1948 committee report (published in the March 1949 JOURNAL, p. 277).

The present organization provides for 18 subcommittees grouped in four classifications, as outlined in the 1950 A.W.W.A. Directory, pp. 44-49. The Committee on Water Works Administration consists of a committee chairman, the general chairmen of the four groups and the chairmen of the active subcommittees. Other subcommittee members do not participate. It is the aim of the committee to anticipate member interests in establishing a long-term policy of continuing activities; to maintain close cooperation with the Committee on Water Works Practice; and to encourage obvious member demand for such activities as are performed by task groups of the Water Works Management Div.

The work of the coordinating committee has been widened by the creation of "task groups" subordinate to standing committees. The chairman of a task group is not a member of the Committee on Water Works Administration but works within the province of the Water Works Management Div. or the Water Resources Div.

During the year the following task groups were created:

A1.D-1—Protection of Sprinkler Systems From Freezing: C. J. Alfke, *Chairman*

A2.E-1—Safety Practices: R. J. Faust, *Chairman*

A4.D-1—Industrial Water Use: H. E. Hudson, *Coordinator*

A4.D-2—Domestic Water Use: L. J. Hoffman, *Coordinator*

At the 1950 Philadelphia Conference, thirteen topics stemming from the committee's activities, either directly or indirectly, were presented at the various sessions:

COMMITTEE	WORK	PUBLISHED IN JOURNAL
A1.C	—Report: Water Use for Air Conditioning	Dec. 1950, p. 1111
A1.C	—Discussion: Air Conditioning	
A1.D }	Paper: Public Fire Protection as a Factor in	
A4.B }	Rate Making	Nov. 1950, p. 981
A1.D }	Paper: Survey of Charges for Private Fire	
A4.B }	Protection	Nov. 1950, p. 1009
A4.A	—Report: Annual Reports of Water Departments	Aug. 1950, p. 715

COMMITTEE	WORK	PUBLISHED IN JOURNAL
A4.B	—Paper: Demand and Distance Factors in Rate Making	Nov. 1950, p. 1003
A4.B	—Panel Discussion: Report of Committee on Water Rates	
A4.B	—Paper: What Does It Cost to Provide Service to Special Class Customers?	Jan. 1951, p. 65
A4.D	—Paper: Water Consumption in Multifamily Apartment Houses	Oct. 1950, p. 921
A4.D	—Panel Discussion: Management Experience With Metering Multiple Dwellings	Oct. 1950, p. 913
A4.D	—Paper: The Magnitude of Industrial Demands for Process Water	Aug. 1950, p. 777
A4.D	—Paper: Recording Customers' Use and Loss of Water	Oct. 1950, p. 927
General	—Open Meeting: Committee on Water Works Administration	

The year saw much work carried forward by the various subcommittees:

A1.A—Constitutional and Statutory Aspects of Municipal Water Works Organizations. An analysis of state and provincial laws affecting water works operation and management is being prepared.

A1.B—Radio and Mobile Communication Facilities for Water Works. The regulations of the FCC have not caused any concern among water utility users during 1950. No special activity is now being pursued except that of careful attention to civil defense requirements as they affect water works practice.

A1.C—Water Use in Air Conditioning and Other Refrigeration. This subcommittee developed a model ordinance for municipalities to use in regulating the use of water for air conditioning. The report of the committee, as well as the model ordinance, was published in the December 1950 JOURNAL.

A1.D—Water Use in Fire Prevention and Protection. A task group,

A1.D-1, reviewed conditions affecting the use of antifreeze materials in sprinkler systems located in unheated buildings; it is now preparing a special report for the guidance of water works executives.

A2.A—Public Relations. Two new issues of *Willing Water* were published during 1950. A booklet entitled "What Price Water" was also prepared, at the direction of the board, as a promotional tool for use of the industry in developing public acceptance of increased water rates. This is now available. In October 1950 the first issue of "Defense News" was distributed to all members residing in the United States, Cuba and Canada.

A2.C—Compensation of Water Works Personnel. Under a special appropriation, the A.W.W.A. staff, with the guidance and approval of the chairman, distributed to 499 water works executives an inquiry into rates of compensation, department income and related matters. As of the end of 1950, 270 reports had been received. These will be fully analyzed and reported at the Miami Convention.

A2.D—Pension and Retirement Plans. Chairman Maffitt filed a review of 1949 legislation on pension and retirement matters which was published in the October 1950 JOURNAL.

A2.E—Safety Practices. A special task group has been appointed to study safety practices in other fields and will recommend similar practices for the water works industry. It is planned to set up national and sectional committees to promote safety work on an association-wide basis.

A3.D—Water Main Extension Policy. Little work was done during the year. The last report of this subcommittee was published in the August 1949 JOURNAL.

A4.A—Water Department Reports. A final report was published in the August 1950 JOURNAL. The subcommittee will continue active until the report is discussed at section meetings. It is hoped that many water departments will follow the committee's recommendations for preparing annual reports.

A4.B—Water Rate Schedules. The work of this committee is of great importance to the water works industry. Material presented at the 1950 Philadelphia Conference was published in the November 1950 JOURNAL. The work of the committee continues. Liaison is maintained with a rates committee functioning under the Sanitary Engineering Div. of the American Society of Civil Engineers.

A4.D—Water Consumption.

A4.D-1, Industrial Water Use. A task group operating under the Water Resources Div. *A4.D-2, Domestic Water Use.* A task group operating under the Water Works Management Div. These two task groups are both active at present. The national interest in water use and conservation has made it essential that the water works

industry develop, to the fullest possible extent, authoritative information concerning specialized water use.

Topics considered for presentation at the 1951 Miami Conference are being discussed by committee members, and with other groups of the association interested in the conference sessions, particularly the Publication Committee. The following subcommittee activities may furnish program material:

A1.C—Water Use in Air Conditioning and Other Refrigeration. A consideration of measuring devices to indicate maximum demand.

A2.C—Compensation of Water Works Personnel. An analysis of replies to inquiries sent out during the year.

A2.E—Safety Practices. A paper or panel discussion on the work of the task group.

A4.B—Water Rate Schedules. Committee report.

A4.D—Water Use. Reports on the work of the two task groups.

Activation Contemplated

During the meeting of the committee at the Miami Conference, the activation of the following subcommittees will be carefully considered:

A1.D—Water Use in Fire Prevention and Protection. Although this subcommittee is considered "active," and has an advisor, no committee men have been assigned to it. With the activation of Committee A4.B (Water Rate Schedules), Committee A1.D should be activated to cooperate with it in the study of overall rate schedules for utilities. Fire protection rates will also be considered at some time in the future.

A task force is considering protection of sprinkler systems from freezing;

and it is essential that the subcommittee be established to review the work of the task group and consider other phases of the subject.

A2.B—Management Relations. It is believed that this phase of labor relations is a natural outgrowth of, and corollary to, our continuing program on public and personnel relations. This committee should therefore be activated to cooperate with subcommittee A2.A and carry its work to the "local level" and the various organizations of the water works utility.

A2.E—Personnel Safety. This new subcommittee studies problems of personnel safety and physical working conditions. Although a task group is now considering this subject, a committee should be formed to direct further study.

A3.A—Taxation and Fund Diversion. The need for action in this field is daily becoming more apparent to those in the management field. [Ac-

tivation was authorized during the 1951 Annual Meeting of the Board of Directors—Ed.]

A3.C—Cost Trends. Like taxation and fund diversion, this subject is daily becoming more important to those responsible for financing water utilities. Inflationary trends continue to be ominous.

A4.D—Water Consumption. The continued interest in, and discussion of, water conservation makes it essential that a study of water consumption be made by those most interested in water conservation—water works administrators. Two task forces are now actively engaged in this work and the activation of this committee will provide the proper outlet for their activity.

The activation of these subcommittees leaves but two committees inactive:

A1.E—Construction, Equipment, and Material Contracts.

A3.B—Valuation and Depreciation.

Report on Publications

For the Year Ending December 31, 1950

A report on the publishing activities of the Association submitted to the A.W.W.A. Board of Directors on January 15, 1951, by Eric F. Johnson, Assistant Secretary.

TOWARD the end of 1950, the JOURNAL began to feel the impact of a new national emergency, not only in increased prices but in the loss of its Associate Editor to the armed forces. Year's end, nevertheless, found expenses below and income far above budget estimates.

Two special publication projects were completed during the year: the second edition of the manual, *Water Quality & Treatment*, which was published December 15, and the 1950 edition of the biennial *Directory*, which was issued as Part II of the December issue of the JOURNAL.

Sales of books were slightly off during 1950, due principally to a reduction in promotional activity, but specification and reprint sales soared to new highs.

A detailed report of the publication projects of the Association follows:

1. The Journal

a. *Contents.* As scheduled at the beginning of the year, the overall size of the JOURNAL was, in 1950, increased 160 pages over its 1949 size, its total of 2,496 pages making it the largest volume published since 1943. A small portion of this increase was allotted to the text section, increasing the total number of articles printed from 141 in 1949 to 149 in 1950. The 131 technical articles in this group included 34 Annual Conference papers, 78 Section

Meeting papers and 19 contributions. The other 18 were official Association documents or reports.

In response to readers' requests, the abstracts section, which now appears in the advertising pages, was expanded, and a special abstracts index was printed in the December issue. Reduced to 85 pages in the economy drive of 1949, abstracts were given 134 pages of space in 1950, an increase of almost 60 per cent.

The largest gain in size was made in the news and advertising section, where 134 pages were added to accommodate 69 additional pages of advertising. This expansion was, of course, helpful in providing more space for the abstracts, but, if the paper shortages and quotas of World War II are again experienced, it will be necessary to reduce the size of this section by facing advertisements so that a maximum of space for technical material may be provided.

As no paper restrictions have yet been imposed, it is proposed to continue the JOURNAL at its present size for 1951.

b. *Cost.* Despite the imposition of a printing price increase of approximately 7½ per cent as of November 1950, JOURNAL costs were held to \$48,985.02 compared with a budget of \$49,500, mainly through savings in paper and production costs. Because of the larger size of the JOURNAL, and the

increase from 9,036 to 9,600 in average number of copies printed, total costs were considerably above the \$43,272.19 in 1949 and the \$39,392.84 in 1948. Cost per thousand pages, however, remained exactly the same as in 1949 at \$2.01, although increased size forced the price per copy up from 39.9¢ to 42.5¢ during the year. At year's end, the printing cost index, based on 1943 prices, averaged 188, compared with 174 at the beginning of the year; and it is on this higher rate that the 1951 budget is based.

c. *Income.* JOURNAL income from all sources considerably exceeded expectations, but by far the most gratifying and most significant gain was the more than 25 per cent increase in advertising income: from \$57,131.09 in 1949 to \$71,561.50 in 1950. Contributing to this increase, of course, was the 15 per cent increase in rates imposed as of January 1950; but it was expected that contract protection requirements, and losses in space sales, would hold the yield somewhat below the full 15 per cent for the first year. Actually space sales averaged 68.2 pages as against 1949's 62.4 pages per month, an increase of almost 10 per cent.

With contracts totaling more than \$55,000 already in hand, it is expected that 1951 advertising income will reach \$74,000, based on the 1950 rates, which must now be maintained through the year. Whether or not another rate increase should be made in 1952 depends, of course, upon what happens to the price structure during the balance of 1951, as well as upon the JOURNAL's circulation gain. The possibility of a paper shortage that will force a facing of advertisements, at a savings in printing costs, may obviate a rise or make

it undesirable. At any rate, it is felt that any direct action to increase rates should be postponed until midyear, when a better picture of 1952 business trends will be available.

2. The Directory

Although the 1950 edition of the biennial *Directory* listed approximately 17 per cent more members and included a new "Directory of Consultants," reduction of the type size of the address lists made it possible to cut the overall size 64 pages, from 384 in 1948 to 320 in 1950. It is felt that this reduction in bulk plus the sturdier cover makes the book a more satisfactory one for continued reference.

Contents included 157 pages of membership lists, compared with 1948's 226; 73 pages of other Association data, compared with 62; and 90 pages of advertising section, compared with 96. The type size of the reading material was, of course, kept the same; only that of the reference material, which would not involve prolonged reading, was reduced.

Economies of space made possible by the smaller type size did not greatly affect unit costs, as smaller type is more expensive. Thus, total costs were \$7,905.23—\$95 below the budget, but far above the total of \$6,610.98 in 1948, when the printing cost index was 29 points lower. Cost per thousand pages showed a comparable increase, from \$1.76 in 1948 to \$2.20 in 1950, but cost per copy for the smaller book was only 71.2¢ compared with 68.5¢ in 1948. Meanwhile, an advertising income totaling \$3,679.50 brought the net cost of 11,100 copies down to 37.9¢ per copy compared with 35.9¢ in 1948, and 46.1¢ in 1946, when no advertising was sold.

Although the Directory has now been reduced to a size that can be handled without too much difficulty by the user, it still appears to be too large a load for the printer's plant to produce on a reasonable schedule and too large, too, to be absorbed by the JOURNAL staff without major disruption of other activities. A great deal of thought has been given to the possibility of producing the membership list portion of the Directory by a different printing process, direct from typewritten copy, but cost of equipment and various production difficulties have indicated that it is not feasible at the moment. A better possibility for meeting the objections from both the printer's and the staff's point of view, would be to split up the present Directory into two portions, published in alternate years, thus distributing the present work load more evenly over the two-year period now covered by a single issue. This change would mean the continued publication of the membership lists in the even years, as called for by the By-Laws, and publication of such other Association data as Committee Lists, Buyers' Guide, and Directory of Consultants in the odd years. And either or both of these publications could be opened to advertising.

3. Specifications

In 1950 six of the water purification chemical specifications—those for sodium chloride, trisodium phosphate, bauxite, sodium fluoride, ferrous sulfate and ammonium sulfate—were approved and published in the JOURNAL. All are now available in reprint form as booklets.

Sales of specifications again far exceeded expectations, topping the budget by more than 50 per cent. Total

income was \$4,649.78 compared with last year's record \$3,163.79 and 1948's \$1,801.86. How much of this increase is attributable to increased construction activity and how much to improved inventory controls and such innovations as this year's distribution of review copies is difficult to estimate. But there is little question that greater and greater attention is being given to A.W.W.A. standards.

During 1950, also, 100 of the specially imprinted looseleaf binders introduced in 1949 were sold, indicating the desirability of continuing to stock this item.

4. Journal Indexes

During the year, 37 copies of the 1881-1939 Index were sold, compared with half that number in 1949, leaving a balance of 201 copies in stock. During the same period the sale of 12 copies of the 1940-44 supplement left its stock at 232.

Preliminary work on a 1940-49 supplement was undertaken during the year, but lack of staff time left the job far from completed. It is now thought that a 1940-50 supplement can be issued during 1951 if that appears more urgent than other publication projects; but detailed plans must await investigation of the availability of personnel, printing capacity and paper. If and when a more or less definite production schedule and price estimate can be made, a proposal will be presented to the Board.

5. Standard Methods

During 1950, almost 2,600 copies of the ninth edition of *Standard Methods for the Examination of Water and Sewage* were sold, increasing total distribution of this edition to more than

15,000 copies and leaving a balance of approximately 2,300 in stock.

Work on the tenth edition, under Chairman Harry A. Faber of the Joint Editorial Board, has progressed according to schedule, so that the manuscript should be ready for the printer by the end of 1951.

6. Accounting Manual

Sales of the *Manual of Water Works Accounting* totaled 67 during 1950, compared with 160 sold during 1949, the drop being attributable to the lack of special promotion during the year.

7. Survival and Retirement Book

Sales of *Survival and Retirement Experience With Water Works Facilities* also dropped, from 125 in 1949 to 50 in 1950. Approximately 400 bound and 1,000 unbound copies of this book are now in stock.

8. The Quest for Pure Water

During 1950, sales of *The Quest for Pure Water* totaled approximately 200, leaving some 300 bound and 1,000 unbound copies of the second printing in stock. Sales during 1951 are expected to continue at about the same rate, so that no further binding will be required until 1952.

9. Glossary

The A.W.W.A. supply of the *Glossary—Water & Sewage Control Engineering* has been sold out, the last few copies of a stock of 1,000 being disposed of during 1950. Orders received from now on will be referred to the other sponsoring societies—American Public Health Assn., American Society

of Civil Engineers and Federation of Sewage Works Assns.—pending the development of plans for a second edition.

10. Water Quality & Treatment Manual

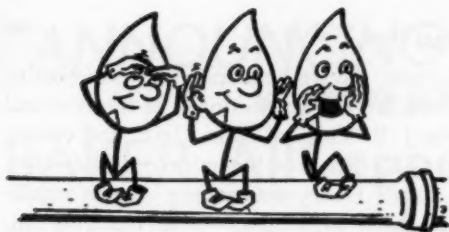
On December 15, 1950, the second edition of *Water Quality & Treatment* was finally eked out on paper stock remainders collected from three different New York City suppliers. This printing was limited to 2,000, so that any serious errors could be corrected before a full supply was produced.

To avoid any conflict with other year-end activities, full-scale promotion of the book was postponed until 1951. Announcement of the publication was made, however, by sending review copies to all publications in the field, by offering examination copies to sanitary engineering professors who might be interested in the book as a text, and by following up the five-year backlog of orders and inquiries. By these means some 250 copies had been distributed by the end of the year.

Paper stock adequate for a second printing of about 7,000 copies has already been purchased and received, but it seems wise to postpone plans for a second printing until a better estimate of demand can be made.

Board Action Taken

The Board referred action on setting 1952 advertising rates to the Ways and Means Committee, and action on the possibility of splitting the present directory into two separate publications to the Publication Committee.



Percolation and Runoff

Once upon a time in a town with the unlikely but descriptive name of Kennebunkport in a state with the somewhat likelier name of Maine, there was a long, narrow living room. And on the wall of this long, narrow living room, there was fastened a plaque of brass, which read:

In this room, Oct. 22nd, 1949, Henry Gross dowsed three fresh-water domes (Royal Barracks, Jennings, Clayhouse) on a map of Bermuda, an island on which no potable spring-water supposedly existed. In Bermuda, Dec. 7, 1949, Henry found the domes as dowsed in Kennebunkport. Sir Stanley Spurling, Sir Howard Trott and Kenneth Roberts became partners to open them; and after many doubts and delays, Royal Barracks came in on Feb. 11, 1950; Jennings, March 10, 1950; Clayhouse, March 23, 1950. April 27, 1950, Clayhouse flowed 44 gallons a minute—a daily 63,360 gallons wasting its sweetness on the desert air.

And that, with no end of trimmings, is the tale of *Henry Gross and His Dowsing Rod** as told by the man who owned the living room—Kenneth Roberts, whose authorship of such best-sellers as *Northwest Passage* and *Oliver Wiswell* has earned for him the reputation of master of historical fiction and whose sponsorship of Henry Gross has already earned for him honorary membership in the Elves, Leprechauns and Little Men's Science Society of Upper Downer.

Don't get the idea from this introduction, though, that Kennebunkport Ken is attempting to invade the territory of Grimm or Andersen. On the contrary, the book is really lousy with scientific method, incontrovertible evidence and even some "careful documentation," all of which prove to its author's satisfaction that, as the Nobel prizewinning French physiologist, Charles Richet, has said: "The action of the rod is uncontestably true. The action of the rod cannot be denied. The action of the rod is as certain as all chemical phenomena. There is no longer any doubt that the movement of the rod indicates exactly the whereabouts of subterranean veins."

What we liked about the book was the fact that, in it, someone finally took a definite stand on dowsing. Too bad it had to be *that* stand and too

* Doubleday & Co., Garden City, N. Y. (1951), \$3.

(Continued on page 2)

(Continued from page 1)

bad it had to be Kenneth Roberts, who, though he admits to the support of such eminent scientists as mathematician Horace Levinson of the National Research Council, parapsychologist J. B. Rhine of Duke Univ., and others, is no scientist himself and just possibly may not be entirely disinterested. After all, it was Ken himself who made Henry outstanding—not in infallibility of course, but in the prodigiousness of his talent—by encouraging him to develop his technique along the lines followed by the ancient masters of the art. Thus, Henry can now get all kinds of answers concerning the availability, exact location, quality and source of water anywhere, from wherever he may be, whenever you may require it. Henry is a bit unusual too in being able to dowse by map or sight unseen, dowse the difference between fresh and spoiled anchovies, dowse out people for whom he is looking and dowse even the results of the World Series, but Patron Roberts does point out that he can only swear by Henry's infallibility in his work with water—but water, water everywhere.

To protect Henry from possible exploitation by people like you, Ken has incorporated him as "Water Unlimited," and if one day now you find that name in the Professional Services section of this publication you'll know we have finally gotten off the fence. Meanwhile, as a fitting conclusion to this report, we'll hope that:

They live happily ever after.

Citizen of the Year 1950 at Spartanburg, S.C., was A.W.W.A. member Bob Simms, superintendent of the city water works. But we're not congratulating Bob for a distinction he well deserved, we're congratulating the people of Spartanburg for recognizing that fact. And, by the way, how better get public relations?

Water supply is still front-page news in the New York-New Jersey metropolitan area. Jersey newspapers featuring the opening session of the state's 175th Legislature put water supply development plans high on the list of priority tasks, as did the Legislature itself. And in New York the big news was full reservoirs—with front-page spreads to illustrate so auspicious an event as the first spillover in the Croton system since 1949. Meanwhile fluoridation, too, provided news—news of a dozen Jersey superintendents' meetings to give it active consideration, news that the Philadelphia city council is poised to act on the matter and news that New Rochelle has already acted.

All this, and main breaks too, may serve to sustain public interest where it is really needed behind such projects as the four-state "Incode!" plan for exploiting the Delaware. The public interest in public interest, however, isn't often predictable, if even determinable.

(Continued on page 4)

ANNOUNCING... an important addition to pipeline practice— BAKER AllCopper FITTINGS for Transite and Century Pipe

AllCopper FITTINGS* are designed and built to meet the requirements of Transite or Century Pipe practice. They incorporate the simplicity and ease of Simplex Coupling usage with the corrosion resistance and light weight of a pure copper fitting.

AllCopper FITTING USE—The Fittings are identical in principle with that of the Simplex Coupling. Inside diameters of the AllCopper Fittings are equal to those of the Simplex of each class. Note from the illustration above that a pair of lugs is provided on each side of the barrel of each fitting. To couple in the field—(1) Position the rubber gasket furnished with the pipe over the pipe end; (2) lag your regular coupling puller over the line; (3) place the coupling hooks over each of the lugs on the fitting barrel; (4) simply jack the pipe the required length into each fitting and the joint is complete. All bells are 5" deep.

AllCopper FITTING ADVANTAGES—The use of AllCopper Fittings throughout your system means that the advantages of flexible Simplex joints are yours throughout the range of Tees, Crosses, Elbs, Laterals, Threaded Risers, Reducers and a complete range of line requirements. All caulking, poured joints, tamping and other joint preparations are eliminated. Your cost in coupling pipe with the AllCopper Fitting is that of coupling straight lengths with a Simplex.

These economic advantages make these couplings a most important addition to Transite and Century pipe practice. To this must be added the many lifetimes of service that only copper can offer.

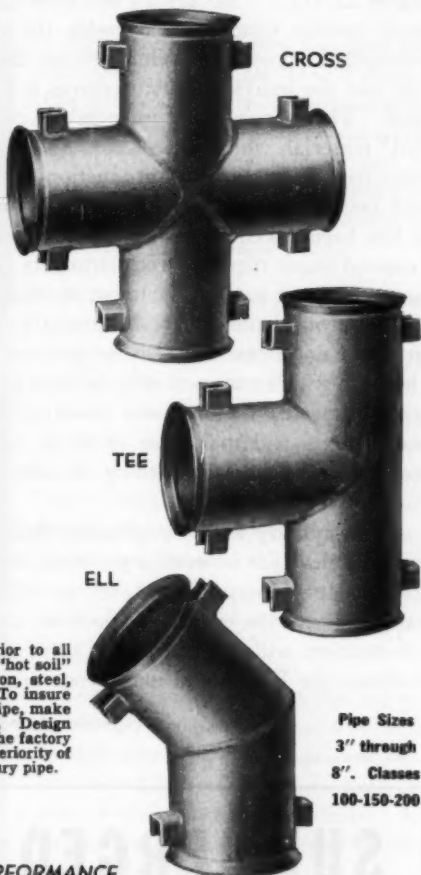
Corrosion engineers agree that copper is superior to all other common metals in resistance to corrosion, "hot soil" and other trench conditions that destroy cast iron, steel, brass and other metals used in piping today. To insure your investment in the use of cement-asbestos pipe, make sure that Baker AllCopper Fittings are specified. Design and corrosion engineers are invited to contact the factory for further engineering information about the superiority of AllCopper Fittings for use with Transite or Century pipe.

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(Continued from page 2)

Protection of technical information on a voluntary basis has been facilitated by the provision of a new government information service. Private citizens who want to know whether the release of technical information in their possession will be harmful to the country's security may send their queries—together with pertinent manuscripts, plans or documents, if available—to the Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C. That agency will refer the matter to the government bureau most directly concerned, assemble the comments, and furnish a reply as promptly as possible. While official, the government's advice is not binding, and the individual who receives it remains free to make his own decision. The service is not intended, of course, to be concerned with "classified" material, which is protected by law, but rather with data on advanced industrial developments, production technology, and strategic equipment and installations. One example offered by OTS of the type of question it has been asked to resolve is the problem faced by a city official who received many requests from strangers for detailed information concerning fire, police and water department operations. He felt that such information in the wrong hands might be contrary to the national interest. The program is not intended, also, to circumvent other governmental advisory channels which may normally be used by certain individuals, nor is it normally expected that authors about to release manuscripts to recognized publications will make use of it, as such publications usually have had experience in the safeguarding of information.

Everybody wants engineers these days, so if you are one and want a job, a new job or even a position, send us a résumé of your education, experience and expectations, tell us when you'll be available, and we'll arrange to have the supply of you meet some demand for you. And all this information will, of course, be kept just as confidential as you insist. Address the Editor and mark your envelope "Personnel."

(Continued on page 6)

SUBMERGED PIPE LINE CONSTRUCTION

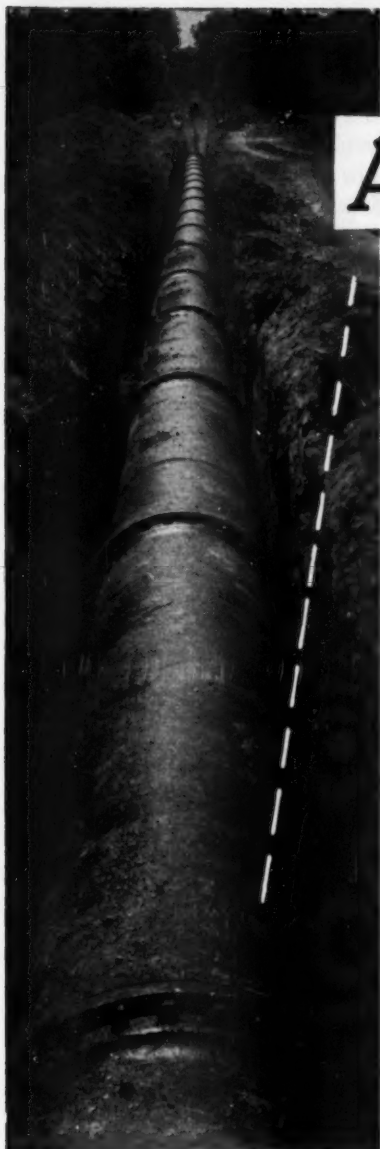
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As America's largest individual cast iron pipe foundry, ACIPCO manufactures a complete line of cast iron pipe and fittings in diameters from 3" to 48", inclusive. The pipe which is made by the Mono-Cast centrifugal process is equipped with any of a wide variety of joints including Bell and Spigot, Doublex Simplex, Molox Ball and Socket, Roll-On-Rubber Ring, Screw-Gland, and Flanged. All ACIPCO pipe is manufactured under close control to meet nationally recognized standard specifications.

Being cast iron, ACIPCO pipe enjoys an enviable reputation. Cast iron pipe has had over three hundred years of service abroad and more than one hundred years of service in the United States. It serves equally well beneath crowded city streets or in cross country installations.

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(Continued from page 4)

"What Price Water?"—a good question given a good answer in A.W.W.A.'s new public relations booklet of that name—has been distributed to all members of the Association and will in the next few months be put in the hands of thousands and thousands of their customers, but we're willing to bet doughnuts to dollars (at the present rate of exchange) that not one in 10,000 will have noticed, without this hint, an artist's misconception that was spotted in two seconds by A.W.W.A.'s prexy, Vic Weir. As a matter of fact, having mentioned the subject, we are also willing to bet now that not one of the artist's conceptions misses a "mis-" of one kind or other. But the fact will remain, we think, that the booklet is an effective tool in public relations.

"Name Your Poison" has always been an invitation to drink, but we had no idea anyone took it literally until we saw an *Associated Press* story based on the 1950 annual report of the town of Tyler, Minn. During the year, it appears, municipal sales of hard liquor dropped \$3,500 (about 175 gal.), while sales of water increased \$258 (well over 1 mil.gal.) and business at the municipal hospital took a substantial jump to \$92,274. But before you jump, too, to any too hasty conclusions, be advised that on second thought we were able to ascribe the unhappy relationship to the demands of hydrotherapy.

Looking at the data from a less defensive position, however, we might be willing to give up our assumed teetotalism to jump on the bandwagon of conservationism. In so doing, of course, we need only point out that, whereas: in the manufacture of whiskey, about 80 gal. of water are required to produce 1 gal. of whiskey; in the production of teetolism, about 6,750 gal. of water are required to save 1 gal. of whiskey.

Name Your Poison!

Digging a hole to China was once a favorite speculation of ours to demonstrate advanced geographic sophistication, so now when we read that earthquakes in Asia have affected the water level in deep wells of Texas and Florida, we aren't at all surprised. In fact, learning that the levels near San Antonio rose 1 ft. and then dropped 1.3 ft. below normal, we're virtually willing to bet that some Chinese well showed a corresponding rise. So if an atom bomb ever hits Korea, you'd better try to hold your water.

Jack J. Hinman has completed a session as visiting professor of sanitary engineering at the University of North Carolina and is proceeding to Guayaquil, Ecuador, where he is replacing Rene J. LaMarre (Oct. P&R, p. 2) as superintendent of filtration. LaMarre resigned his post with the new plant to return to the U.S.

(Continued on page 8)



Has Your Water Supply System?

From the time the first pawn moves out in a chess game till the king is checkmated it is a complete campaign, not just a series of unrelated moves. Every move of every piece is planned in advance to win the final victory.

Also a pipe rehabilitation program is not just a series of individual jobs. It is a complete campaign designed from start to finish to restore your system to best possible operating efficiency at the lowest possible cost.

Whatever your requirements, Pittsburgh Pipe Cleaner Company and only Pittsburgh Pipe Cleaner Company can provide all of the services.

Most lines require only cleaning and coating, some may need repairs and replacement, and others complete replacement. Whatever the requirements of your system let us demonstrate to you what we can do.

- I ENGINEERING SURVEY
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(Continued from page 6)

T. C. Hoppe, formerly water treatment engineer for Kimberley-Clark Corp., has joined the Kansas City consulting firm of Black & Veatch.

W. W. Brush, editor of *Water Works Engineering* and treasurer of A.W.W.A., has been awarded honorary membership in the Municipal Engineers of the City of New York. Before entering the publishing field in 1934 he had served for seven years as chief engineer of water supply in New York's Dept. of Water Supply, Gas and Electricity. He had joined the municipal engineering staff in 1894, when the then city of Brooklyn had its own Bureau of Water Supply, and was made deputy and acting chief engineer of the city-wide organization in 1910.

The First Seminar for European Sanitary Engineers, held at The Hague, Netherlands, November 27–December 2, under joint auspices of WHO and the Rockefeller Foundation, devoted a good share of its attention to the advisability of unifying and coordinating research work on such vital questions as the "total management of the water economy." Contributing to the water supply and treatment session were delegates from Italy, Finland, Yugoslavia, Iceland, Sweden and the United Kingdom.

(Continued on page 10)

Now Available: **WATER QUALITY & TREATMENT**

Second Edition—Revised and Enlarged

A.W.W.A.'s manual of *Water Quality and Treatment* brought up to date, with chapters on: source characteristics; aquatic organisms, quality standards, stream pollution and self-purification, impounding reservoir control, aeration, coagulation, mixing and sedimentation basins, disinfection, taste and odor control, filtration, scale and corrosion control, softening, iron and manganese removal, boiler water treatment, fluoridation, and treatment plant control. With four appendices and an index, that makes 451 pages.

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In a country as big as ours millions of dollars are lost through faulty and inefficient water metering. For more than 65 years Hersey has been on the job making Water Meters and through this organization have come many developments that have made water meter history.

Our engineering department, ever alert to improved efficiency at a constantly decreasing maintenance cost, gives you today what we think is the best Water Meter in the country. Ask experienced water works officials who use

HERSEY WATER METERS

HERSEY MANUFACTURING COMPANY

SOUTH BOSTON, MASS.

(Continued from page 8)

More than a mixer and a chaser, water service now provides entertainment, too, to the barflies of Onaga, Kan., and other cities of the Missouri Valley area. The answer is TV—the waves of which, from Kansas City's station WDAF-TV, some 85 miles away, skipped over Onaga by way of its outlying hills until an enterprising appliance dealer named Grim climbed the local water tower to intercept them. With an eye to boosting his sales, Grim made arrangements with the town authorities which permitted him to erect a 25-ft. mast antenna atop the community's 100-ft. elevated water tank, install booster equipment to amplify the weakened Kansas City signal and string 3,500 ft. of coaxial cable to connect his first six customers. Now at Trenton, Mo., Riley, Kan., and other communities in the area, water tanks are being eyed and tried. And though the idea of a master antenna system wasn't exactly new, the Grim one of piping the ridiculous as well as the sublime from the same structure was definitely an innovation.

By thus making possible and practicable a new type of entertainment to its community, a water utility may be considered to be doing itself great good, extending its public relations program even beyond the call of duty. "May be," we say, however, for if our last video viewing gave us a fair sample of what to expect, we'd prefer water hammer and moonlight.

Frank C. Foley, district geologist for the U.S. Geological Survey at Madison, Wis., has been appointed geologist and head of the Div. of Groundwater Geology and Geophysical Exploration of the Illinois State Geological Survey, and also research professor of geology at the University of Illinois. In the former post he succeeds Carl A. Bays, consultant, who resigned. Foley was in charge of locating and developing North African and South European ground water supplies for the Corps of Engineers during World War I, and has been in charge of Wisconsin ground water studies for U.S.G.S. for the past five years.

(Continued on page 12)

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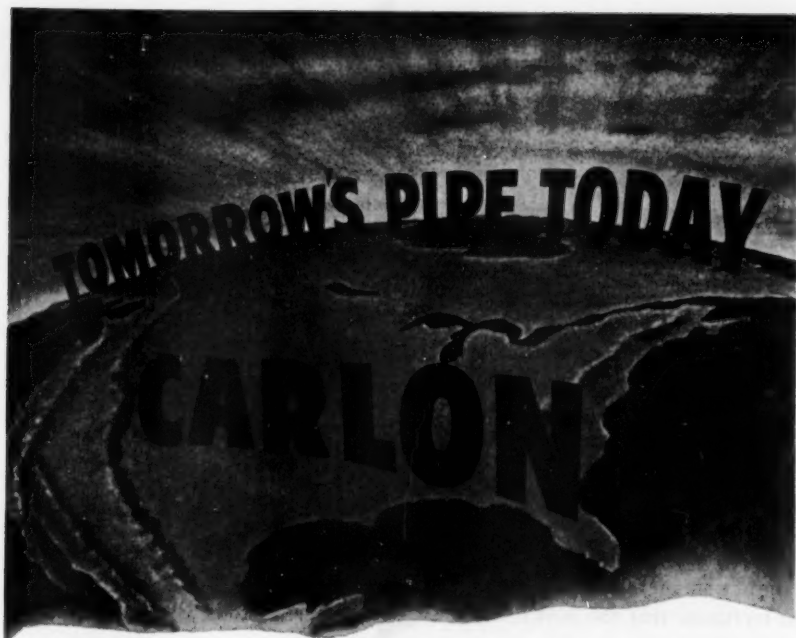
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CARLON PLASTIC PIPE is proving to be the pipe of the future because it eliminates many installation, maintenance, and replacement problems that are inherent in metallic pipe. This durable, lightweight pipe is **guaranteed** against rot, rust, and electrolytic corrosion, and it has a projected service life more than double that of ordinary pipe.

FLEXIBLE and RIGID types of CARLON are available in standard pipe sizes for diversified general piping applications. Flexible pipe is furnished in long lengths that require fewer fittings per installation than any other pipe. Rigid CARLON, shipped in 20-foot sections, can be threaded with standard pipe tools to meet individual job requirements.

CARLON plastic pipe combines long trouble-free service life with ease of handling and installation to become the outstanding contemporary development in the water transmission field.

You are piping for the future when you install CARLON . . . tomorrow's pipe . . . today!



CARLON PRODUCTS CORPORATION

IN CANADA: MICRO PLASTICS, LTD., ACTON, ONTARIO
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CLEVELAND 5, OHIO

(Continued from page 10)

National Weather Improvement Association is certainly a wonderful name for a new organization. We know of at least 150,000,000 people here in the U.S. who have indicated by their everyday conversation that they would be good membership prospects for an association with a name like that. On second look, however, it may not have quite that wide an appeal, for the new NWIA was formed by cloud seeders to promote cloud seeding and, incidentally, "to insure that . . . developments proceed in an orderly fashion and that this great new force is directed into constructive channels for the best interests of the whole country." True, the statement of policy drafted at the organization meeting in Denver in January did note that the group believed "that a program of artificial nucleation and weather-and-crop research can be of immeasurable benefit to many areas in the promotion and development of their economic, social and moral welfare." But nothing specific about vacation skies or golf course cloudbursts. And that business about "economic and moral" welfare makes us wonder if they intend to interfere with so well established a program as "Let's make hay while the sun shines, let's make love when it rains." Furthermore, if we as a nation don't have the weather to gripe about, who knows what we might pick on and to what disastrous end? All of which apparently makes it fortunate that the NWIA isn't what it at first sounds as if it is.

Cloud seeding has, by the way, grown more or less up, and most of the "jest" we spoke three and four years ago has by now become "true word." Thus, Congress is in process of debating a bill to establish a weather control commission, western states particularly are busy with an ever-increasing number of surveys and programs of cloud seeding, not only to make more rain, but to reduce the violence of storms, and New York City either through or despite the employment of a rainmaker has full reservoirs for the first time in more than two years. Now, too, we note that our neighbors to the south are beginning to probe their clouds a bit, and that the Chilean government has pushed forward plans which it hopes will make vast tracts of arid lands arable. Still unrealized, though, is our hope that such cloud bombardment would be substituted for the more fatal kind now again employed. With its umbrellas up, a nation looks somehow less vicious—less able, too, to carry a gun and to keep its powder dry.

T. C. M. Mauch, superintendent of pumping for the Indianapolis Water Co. since 1913 and associated with that organization since 1907, has retired and been presented with one of the prized "diplomas" from the alleged University of Water Supply. Noteworthy is the citation for the "course in marine plant operation" which he was given by the flood of 1913. The degree itself is Gentleman and Scholar, Purveyor of Pressure, summa cum laude.

(Continued on page 14)



In considering replacement vs. reconditioning of a 53 year old line carrying Water to Chula Vista and National City, Calif., the California Water and Telephone Company decided to recondition the line since replacement in addition to the tremendous cost would have meant disturbing many acres of valuable citrus and vegetable fields.

Reconditioning involved a thorough cleaning by National of over 15,000 feet of 24 inch line, after which the entire line was centrillined.

According to information received, the reconditioning has added at least 20 years more of useful life with a marked increase in the volume of water previously handled.

Our engineers will gladly submit facts and figures on how National has solved similar problems for other utilities. Why not write today?

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COUVER, B. C., 505 West 1st Ave., • WACO, P. O. Box 887 • WINNIPEG, 576 Wall St.
• HAVANA • SAN JUAN, PUERTO RICO • BOGOTA • CARACAS • MEXICO CITY.

(Continued from page 12)

Too busy preaching to practice was Les Jackson, manager of the Little Rock, Ark., municipal water works, last month when a record cold snap sent the temperature in his sort of Southern city down to five below zero. Using daily newspapers ads, spot announcements on the three local radio stations and daily newspaper interviews, Les told everybody all about it—how to avoid freeze-ups, that is, by turning off the water and draining the pipes or by keeping at least one faucet running in each room. And his sage advice was well heeded, to the end that consumption jumped from 11 to 19 mgd. In thus limiting freeze-ups to 3,000 homes and bursts to two 2-in. mains, Les performed at least a minor miracle; but in making his own home one of the victims of the freeze-up, he perpetrated a major mirthmaker.

Inasmuch as Les has confessed voluntarily; inasmuch as we understand the rigors of answering emergency calls at the rate of one a minute and keeping 18 emergency crews always at the right place; and inasmuch as he has already taken quite a "beating" on the local front, we aren't even going to mention the incident here.

Picketing the water works ain't de rigueur, but when it's done, it's labor's job, not management's. Yet there is at least one manufacturer who is ready to snatch a sign and start stalking. The grievance involved is "water works are unfair" in wiping out the market for his toilet bowl cleaner by treating their supplies to remove the staining characteristics of natural waters. Well, maybe he isn't quite ready to picket yet, but he has employed a market research organization to find out just what happened to his customers.

Andrew F. Eschenfelder, borough engineer and superintendent for Glen Ridge, N.J., has been reelected president of the N.J. Assn. of Municipal Engineers.

(Continued on page 16)

Manual of British Water Supply Practice

Compiled by the Institution of Water Engineers, London

The essence of the water supply art, as practiced in Great Britain, is well documented in this 900-page compilation. Generously supplied with illustrations and reference lists.

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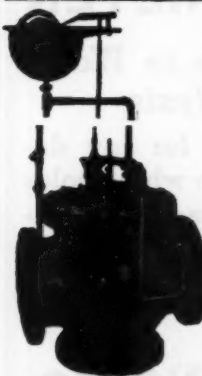
Maintains desired discharge pressure regardless of change in rate of flow

Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

A self contained unit with three or more automatic controls

**COMBINATION VALVE**

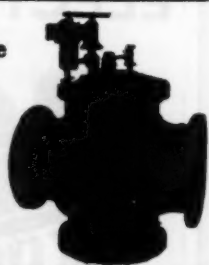
Combination automatic control both directions through the valve.

**FLOAT VALVE**

Maintains levels in tank, reservoir or basin

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Electric remote control—solenoid or motor can be furnished

**REMOTE CONTROL VALVE**

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Packing Replacements for all Ross Valves Through Top of Valve

ROSS VALVE MFG. CO., INC., P. O. BOX 593, TROY, N. Y.

(Continued from page 14)

J. W. Simpson, executive vice president of the Mueller Co., died suddenly at the age of 67. He was stricken while at work at his desk on January 16.

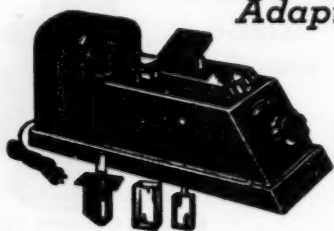
Worthington-Gamon Meter Co. of Newark, N.J., a subsidiary of Worthington Pump & Machinery Corp., has been made a division of the parent organization. It will continue operations under the name of Worthington-Gamon Meter Div.

Ora C. Ayliffe, superintendent of the Fargo, N.D., water works since 1912, has retired. He is 77 and headed the utility since it began operation. Succeeding him as superintendent is Harold H. Behlmer, his assistant since 1943. Behlmer is president of the North Dakota Water and Sewage Works Conference and has had a varied and colorful engineering career.

Ray W. Lindsey, formerly with the consulting firm of Hitchcock & Estabrook, has joined the engineering sales staff of Builders-Providence and Omega Machine Co. in the Wilmette, Ill., office.

(Continued on page 18)

KLETT SUMMERSON ELECTRIC PHOTOMETER

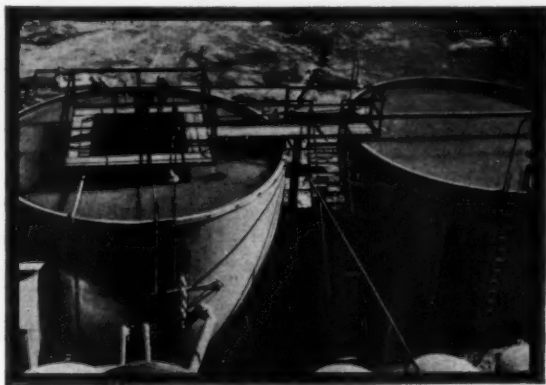


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Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

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In Europe: Recuperation Thermique & Epuration, Paris

(Continued from page 16)

Wanna sell spa juice? Here's your chance! New York State's Saratoga Springs Authority is looking for an individual (legal or actual) to handle the bottling and distributing, or distributing only, of the three natural carbonated mineral waters and the noncarbonated "State Seal" water, which have been handled by the authority itself for the past forty years. Beverage experience is a consideration, but who can provide more than you? Financial responsibility is another. . . . Oh well, applications closed March 8.

Stephen J. Gullo has been appointed assistant vice-president of the Pepsi-Cola Co., in charge of the Bottle Product Control Dept. His responsibilities will include plant sanitation and operation in addition to water treatment.

Alan Drake, formerly chairman of the New York Section A.W.W.A. and commissioner of water at Buffalo, N.Y., died on January 21.

Erickson Chemical Co. has moved its offices to 333 N. Michigan Ave., Chicago 1, Ill.

(Continued on page 20)

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OF
"STERELATOR EFFICIENCY"**

**NO
JOB
TOO
LARGE**



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Actual Users—THE BEST PROOF OF ALL—
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Easy to operate at LOW MAINTENANCE COST.
Everson SterElatorS METER-MIX-FEED Chlorine
accurately for all water sterilizing requirements.
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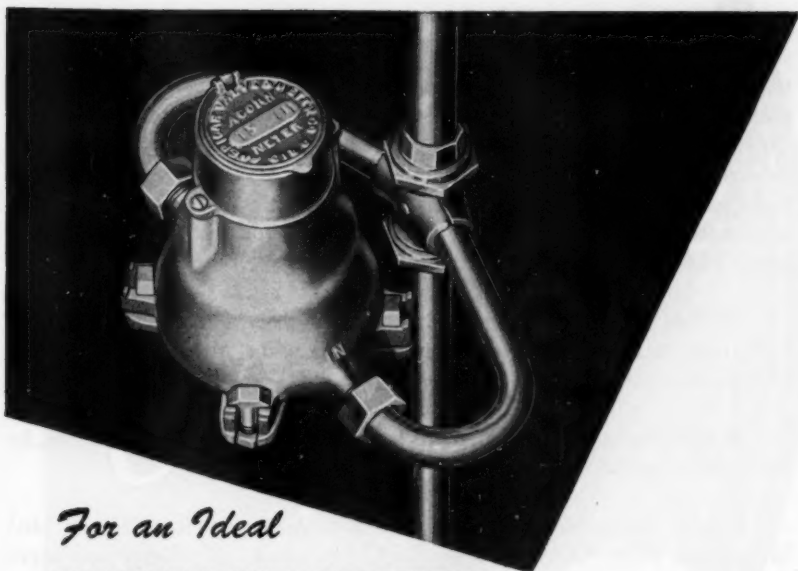
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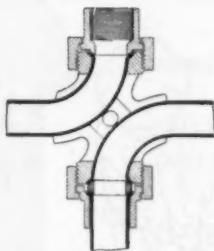
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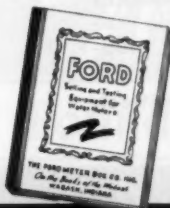
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The Ford Copperhorn provides a permanent, solidly lined-up setting for basement meters installed on vertical pipe lines. Even when meters are changed, the piping remains connected.

The meter is set horizontally and at the most convenient height for easy reading. Smooth waterways—see diagram at right—cut pipe friction or pressure loss to less than half that through ordinary fittings. Economy and permanent, trouble-free service is assured.



Note the smooth all-copper waterways that reduce friction to a minimum. Connections optional for either copper or iron pipe.



FREE Send for Catalog that shows the complete Ford line of economical meter setting products.

FOR BETTER WATER SERVICES



THE FORD METER BOX COMPANY, INC. Wabash, Indiana

(Continued from page 18)

Talk about prize packages, a manufacturer of paper bags made a real one up the other day and gave it away as a packaging exposition souvenir. In the package? Water! Portable potable water! Purpose? To demonstrate the success of a method of waterproofing paper with a new resin. Result? To give us the idea for a new type reservoir; to make us wonder if the "man on the street" didn't come into closer contact with water so collected by those who had rooms on the street side of the hotel; and to give us an eight-line filler.

Walter Byron Lawrence, research engineer at the University of California, has joined the Cleaver-Brooks Co. in Milwaukee, Wis., as project engineer.

A new manufacturing plant is being constructed at Tupelo, Miss., by Rockwell Mfg. Co.

Hagan Corp. has established a new Chicago district office at 1463 Monadnock Bldg., 53 W. Jackson Blvd., Chicago 4. The office will serve the parent company and its subsidiaries, including Calgon, Inc.

(Continued on page 22)



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PIPE"**



The Reading Meter

Henry Gross and His Dowsing Rod. *Kenneth Roberts.*
Doubleday & Co., Garden City, N. Y. (1951) \$3

[See review on P&R, page 1, this issue.]

Applications of Industrial pH Control. *Allen L. Chaplin.*
Instruments Pub. Co., 921 Ridge Ave., Pittsburgh (1950) \$2.50

This 135-page monograph offers a theoretical review of pH control and detailed examinations of aspects of pH control important to process engineers. Elements of good and bad practice, factors causing interference and their elimination are described and illustrated.

Proceedings 56th Annual Public Works Congress. *American Public Works Assn., Chicago 37, Ill. (1950) \$5*

Among the papers presented at the A.P.W.A. convention in New York last October, and published here in a block, are a number of interest to the water utility manager. Public relations techniques, financing of public works, organization and personnel problems, and motor equipment are topics which have general application to municipal utility and service departments.

(Continued from page 20)

Pontusco Corp., until recently owned jointly by U.S. Pipe & Foundry Co. and Cie. de Pont-a-Mousson, France, has come under the complete control of the American firm as a result of an agreement giving to the French organization complete control of Pontusco Corp. of Cuba. Pontusco itself owns all the common stock of the United Concrete Pipe Corp. of California.

Cement-mortar lining of small-diameter pipelines in place is being offered by Pipe Linings, Inc., newly organized subsidiary of American Pipe & Construction Co. The firm is using the patent for lining pipe of 4-in. size and larger owned by the firm of Tate Pipe Linings, Inc., which is now in dissolution. In the eastern U.S. the Centrline Corp. has been licensed to use the process.

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The meter used by thousands of municipalities in the U. S.

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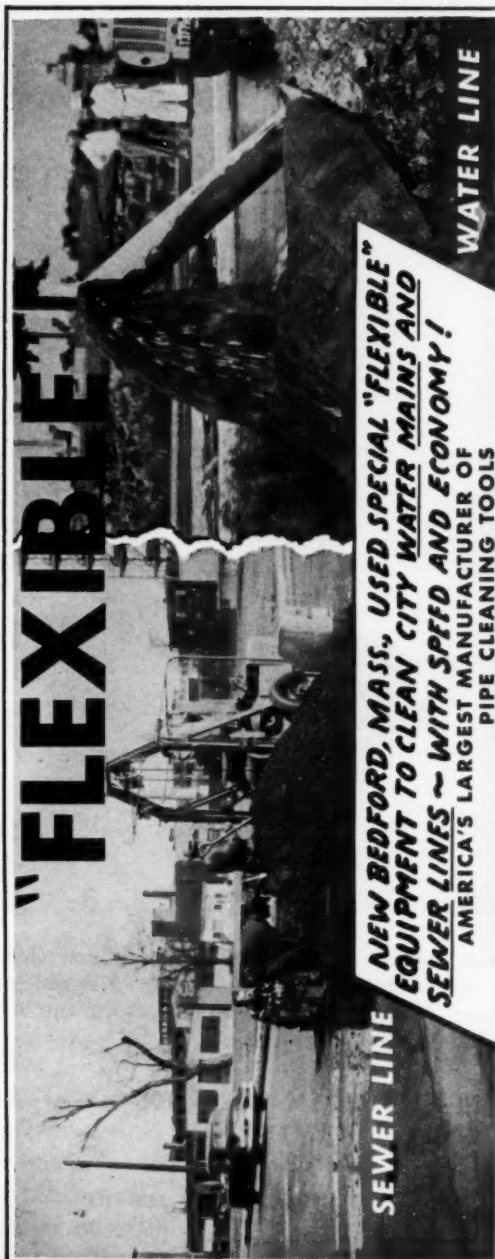
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<p>CAMP, DRESSER & McKEE <i>Consulting Engineers</i></p> <p>Water Works, Water Treatment, Sewerage and Wastes Disposal, Flood Control</p> <p>Investigations, Reports, Design Supervision, Research, Development</p> <p>6 Beacon St. Boston 8, Mass.</p>	<p>FINKBEINER, PETTIS & STROUT CARLETON S. FINKBEINER C. E. PETTIS HAROLD K. STROUT <i>Consulting Engineers</i></p> <p>Reports, Designs, Supervision, Water Supply, Water Treatment, Sewerage, Sewage Treatment, Wastes Treatment, Valuations & Appraisals</p> <p>518 Jefferson Avenue Toledo 4, Ohio</p>
<p>THE CHESTER ENGINEERS</p> <p>Water Supply and Purification, Sewerage Systems, Sewage and Industrial Waste Treatment, Power Development and Applications, Investigations and Reports, Valuations and Rates</p> <p>210 E. Park Way at Sandusky PITTSBURGH 12, PA.</p>	<p>FREESE, NICHOLS AND TURNER <i>Consulting Engineers</i></p> <p>2111 National Standard Building Houston 2, Texas</p> <p>CH-1624</p>
<p>CONSOER, TOWNSEND & ASSOCIATES</p> <p>Water Supply—Sewerage Flood Control & Drainage—Bridges Ornamental Street Lighting—Paving Light & Power Plants—Appraisals</p> <p>351 E. Ohio St. Chicago 11</p>	<p>FULBRIGHT LABORATORIES, Inc. <i>Consultants</i> <i>Chemists and Chemical Engineers</i></p> <p>Industrial Water and Waste Surveys</p> <p>Tel. 5-5726</p> <p>Box 1284 Charlotte, N. C.</p>

<p>GANNETT FLEMING CORDDRY & CARPENTER, Inc. <i>Engineers</i></p> <p>Water Works—Sewerage Industrial Wastes—Garbage Disposal Roads—Airports—Bridges—Flood Control Town Planning—Appraisals Investigations & Reports</p> <p>Harrisburg, Pa. Pittsburgh, Pa. Scranton, Pa.</p>	<p><i>Professional Services</i> (contd.)</p>
<p>G. L. GEISINGER <i>Consulting Engineer</i></p> <p>Water Works—Treatment—Filtration Design—Operation—Reports Laboratory Analysis</p> <p>122 Elliott Ave., W. Seattle 99, Wash.</p>	<p>CHARLES HAYDOCK <i>Consulting Engineer</i></p> <p>Water Works and Sanitation Industrial Wastes Design, Construction, Operation and Management Reports and Valuations</p> <p>2314 Girard Trust Co. Bldg. Broad St. & S. Penn Square Philadelphia 2</p>
<p>GILBERT ASSOCIATES, INC. <i>Engineers and Consultants</i></p> <p>Water Supply and Purification Sewage and Industrial Waste Treatment Chemical Laboratory Service Investigations and Reports</p> <p>New York Reading, Pa. Washington Houston Philadelphia</p>	<p>HITCHCOCK & ESTABROOK, INC. Lester D. Lee, Associate <i>Consultants to Municipalities since 1920</i></p> <p>Water, Sewerage, Paving, Power Plants, Airports, Public Buildings, Surveys and Appraisals</p> <p>241 Sheridan Rd. 521 Sexton Bldg. Menominee, Mich. Minneapolis 15, Minn.</p>
<p>GLACE & GLACE <i>Consulting Sanitary Engineers</i></p> <p>Sewerage and Sewage Treatment Water Supply and Purification Industrial Wastes Disposal Design, Construction, and Supervision of Operation</p> <p>1001 North Front St., Harrisburg, Pa.</p>	<p>HORNER & SHIFRIN <i>Consulting Engineers</i></p> <p>W. W. Horner S. W. Jens H. Shifrin E. E. Bloss V. C. Lischer</p> <p>Water Supply—Airports—Hydraulic Engineer- ing—Sewerage—Sewage Treatment—Municipal Engineering—Reports</p> <p>Shell Building St. Louis 3, Mo.</p>
<p>GREELEY & HANSEN <i>Engineers</i></p> <p>Water Supply, Water Purification Sewerage, Sewage Treatment Flood Control, Drainage, Refuse Disposal</p> <p>220 S. State Street, Chicago 4</p>	<p>ROBERT W. HUNT CO. <i>Inspection Engineers</i> (Established 1888)</p> <p>Inspection and Test at Point of Origin of Pumps, Tanks, Conduit, Pipe and Accessories</p> <p>175 W. Jackson Blvd. Chicago 4, Ill. and Principal Mfg. Centers</p>
<p>HAVENS & EMERSON</p> <p>W. L. Havens C. A. Emerson A. A. Burger F. C. Tolles F. W. Jones</p> <p><i>Consulting Engineers</i></p> <p>Water, Sewage, Garbage, Industrial Wastes, Valuations—Laboratories</p> <p>Leader Bldg. Woolworth Bldg. CLEVELAND 14 NEW YORK 7</p>	<p>THE JENNINGS-LAWRENCE CO.</p> <p>A. P. Harness, Jr. C. C. Walker F. L. Swickard B. I. Sheridan R. L. Lawrence</p> <p>Civil & Municipal Engineers Consultants</p> <p>Water Supply, Treatment & Distribution Sewers & Sewage Treatment Reports—Design—Construction</p> <p>12 N. Third Street Columbus 15, Ohio</p>

<p>JONES, HENRY & SCHOONMAKER (Formerly Jones & Henry) Consulting Sanitary Engineers</p> <p>Water Works Sewerage & Treatment Waste Disposal</p> <p>Security Bldg. Toledo 4, Ohio</p>	<p>Parsons, Brinckerhoff, Hall & Macdonald G. Gale Dixon, Associate Engineers</p> <p>Dams Water Works Sewerage Airports Bridges Tunnels Traffic & Transportation Reports Highways Subways Foundations Harbor Works Valuations Power Developments Industrial Buildings</p> <p>51 Broadway, New York 6, N.Y.</p>
<p>MORRIS KNOWLES, INC. Engineers</p> <p>Water Supply and Purification, Sewerage and Sewage Disposal, Industrial Wastes, Valuations, Laboratory, City Planning.</p> <p>Park Building Pittsburgh 22, Pa.</p>	<p>MALCOLM PIRNIE ENGINEERS Civil & Sanitary Engineers</p> <p>MALCOLM PIRNIE ERNEST W. WHITLOCK RICHARD HAZEN G. G. WERNER, JR.</p> <p>Investigations, Reports, Plans Supervision of Construction and Operations Appraisals and Rates</p> <p>25 W. 43rd St. New York 18, N. Y.</p>
<p>R. M. LEGGETTE Consulting Ground Water Geologist</p> <p>Water Supply Salt Water Problems Dewatering Investigations Recharging Reports</p> <p>551 Fifth Avenue New York 17, N. Y.</p>	<p>THE PITOMETER COMPANY Engineers</p> <p>Water Waste Surveys Trunk Main Surveys Water Distribution Studies Penstock Gaugings</p> <p>50 Church St. New York 7, N. Y.</p>
<p>Roberto Meneses Hoyos & Co. Ground Water Engineers</p> <p>Water Supply Geophysics Test Drilling Flow Tests Explorations Reports Design, Valuations & Supervision</p> <p>Reforma 12 Mexico City</p>	<p>LEE T. PURCELL Consulting Engineer</p> <p>Water Supply & Purification; Sewerage & Sewage Disposal; Industrial Wastes; Investigations & Reports; Design; Supervision of Construction & Operation Analytical Laboratories</p> <p>1 Lee Place Paterson 1, N. J.</p>
<p>METCALF & EDDY Engineers</p> <p>Water, Sewage, Drainage, Refuse and Industrial Wastes Problems Airfields Valuations Laboratory</p> <p>Statler Building Boston 16</p>	<p>THOMAS M. RIDDICK Consulting Engineer and Chemist</p> <p>Municipal and Industrial Water Purification, Sewage Treatment, Plant Supervision, Industrial Waste Treatment, Laboratories for Chemical and Bacteriological Analyses</p> <p>369 E. 149th St. New York 55, N.Y.</p>
<p>THE H. C. NUTTING COMPANY Engineers</p> <p>Water Distribution Studies Water Waste Surveys Trunk Main Surveys Meter and Fire Flow Test</p> <p>4120 Airport Road Cincinnati 26, Ohio</p>	<p>RIPPLE & HOWE Consulting Engineers</p> <p>O. J. RIPPLE B. V. HOWE Appraisals—Reports Design—Supervision</p> <p>Water Works Systems, Filtration and Softening Plants, Reservoirs, and Dams, Sanitary and Storm Sewers, Sewage Treatment Plants, Refuse Disposal, Airports</p> <p>426 Cooper Bldg., Denver 2, Colo.</p>

Membership Changes



NEW MEMBERS

Applications received January 1 to 31, 1951

Angeline, Lawrence J., Foreman, Pumps & Storage, Water Dept., 402 City Hall, Tacoma, Wash. (Jan. '51)

Baur, Oscar, see Terre Haute Brewing Co.

Becker, William A., Salesman, Neptune Equipment Co., 306 E. 8th St., Cincinnati 2, Ohio (Jan. '51)

Belyea, Allan C., Fire Protection Engr., Associated Factory Mutual Fire Insurance Co., 52 Vanderbilt Ave., New York 17, N.Y. (Jan. '51)

Bendix Products Div., Wilbur E. Sanders, Mgr., Production Service Dept., 401 Bendix Dr., South Bend 20, Ind. (Corp. M. Jan. '51)

Berkley, Joseph A., Chairman, Munic. Authority of the Borough of West View, West View, Pa. (Jan. '51) *M*

Breeden, Rex E., Mgr., Culligan Soft Water Service, 321—7th St., Columbus, Ind. (Jan. '51)

Brennan, Robert K., Salesman, Lynchburg Foundry Co., 122 S. Michigan Ave., Chicago 3, Ill. (Jan. '51)

Bruch, Herman George, Water Supt., Box 222, Roseville, Ill. (Jan. '51) *M*

Brungardt, Bernard J., see Hays (Kan.)

Bymer, Wm., see Carmel (Ind.) Water Dept.

Carlough, Harry O., Water Supt., 44 Washington Ave., Suffern, N.Y. (Jan. '51) *M*

Carmel Water Dept., Wm. Bymer, Supt., Carmel, Ind. (Corp. M. Jan. '51) *MR*

Centlivre Brewing Corp., Frank Kloor, Plant Supt., 2501-38 Spy Run Ave., Fort Wayne 3, Ind. (Jan. '51) *PR*

Chandler, Sydney W., Partner, Biggs, Weir & Chandler, 224 N. Congress St., Jackson, Miss. (Jan. '51) *P*

Cochran, Omar Neil, Jr., Engr., Floyd G. Browne & Assocs., 27 Marion Bldg., Marion, Ohio (Jan. '51)

Compton, Wendell C., see Miles Laboratories, Inc.

Dasbach, Donald Lester, Sales Engr., Johns-Manville Sales Corp., 205 May Bldg., Charleston, W. Va. (Jan. '51)

Denny, Cartan Harold, Engr., Water Div., Dept. of Public Utilities, Tacoma, Wash. (Jan. '51) *M*

Dore, Stanley Milburn, Deputy Chief Engr., Allegheny County San. Authority, 502 City County Bldg., Pittsburgh 19, Pa. (Jan. '51) *R*

Dougherty, J. H., Vice-Pres., Canada Iron Foundries Ltd., 921 Sun Life Bldg., Montreal 2, Que. (Jan. '51)

Ellenberger, Charles F., Hydr. Engr., State Public Service Com., Albany, N.Y. (Jan. '51) *MP*

Feierabend, William Douglas, Service Engr., Electric Chemical Co., 566 Nottingham Rd., Syracuse 10, N.Y. (Jan. '51) *P*

Felker, Carl F., Dist. Mgr., Southern Indiana Gas & Elec. Co., Newburgh, Ind. (Jan. '51) *MP*

Ferguson, John Ashley, Partner, Rice, Stokes & Ferguson, Cons. Engrs., 412 Columbia Bldg., Pittsburgh, Pa. (Jan. '51) *MPR*

Forsberg, C. R., Assoc. Prof. of Civil Eng., Univ. of Saskatchewan, Saskatoon, Sask. (Jan. '51)

Fowler, R., Asst. San. Engr., Water Dept., 323 County-City Bldg., Seattle 4, Wash. (Jan. '51)

Friederich, Norbert, Owner, Friederich Constr. Co., 522 E. Main St., Mascoutah, Ill. (Jan. '51)

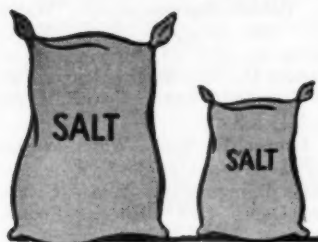
Friedrich, E. J., Mgr., Water Dept., E. 1st St., London, Ohio (Affil. M. Jan. '51)

Fundenberg, C. R., Jr., Asst. Secy., Munic. Authority of the Borough of West View, 441 Perry Highway, West View, Pittsburgh 29, Pa. (Jan. '51)

(Continued on page 32)

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(Continued from page 30)

- Gavlak, Albert J.**, Supt., Water Dept., 13701 Cormere Ave., Cleveland, Ohio (Jan. '51)
- Gilman, Richard Hall, III**, Project Engr., San. Eng. Research, California Inst. of Technology, Pasadena, Calif. (Jan. '51) *PR*
- Graham, William Edward**, Sales Engr., General Electric Co., 570 Lexington Ave., New York 22, N.Y. (Jan. '51) *M*
- Greer, H. C.**, Maritime Repr., Neptune Meters Ltd., 77 Upper Water St., Halifax, N.S. (Jan. '51)
- Griffin, J. W.**, Pres., The Cahaba Water Service Co., Inc., Leeds, Ala. (Jan. '51) *M*
- Haendel, William P.**, Sales Repr., Neptune Meter Co., 4048 W. Taylor St., Chicago, Ill. (Jan. '51)
- Hager, James V.**, Field Engr., Vinson Specialty Paint Co., 522 W. Adams St., Jacksonville 2, Fla. (Jan. '51) *M*
- Hallawell, L. G.**, Mgr., Nappanee Utilities Co., Nappanee, Ind. (Jan. '51) *MP*
- Hays, City of, Bernard J. Brungardt**, City Mgr., City Hall, Hays, Kan. (Corp. M. Jan. '51) *MP*
- Hersom, Ernie**, Mgr., Belmont County Water Dist., Box 158, Belmont, Calif. (Jan. '51) *M*
- Hickcox, A. M.**, Water Distr. Supt., Water Dept., Wenatchee, Wash. (Jan. '51) *M*
- Higgins, Thomas F.**, Serviceman, Water Dept., Central Ave., Massapequa, N.Y. (Jan. '51)
- Hight, Hanford Z.**, Sales Mgr., Dresser Manufacturing Div., Bradford, Pa. (Jan. '51) *M*
- Hill, Clarence F.**, Mayor, Rochester, Ind. (Jan. '51) *MP*
- Homan, John D.**, Engr., 714 S. Orleans Ave., Tampa 6, Fla. (Jan. '51) *MPR*
- Hoper, Clarence H.**, Asst. Chief Engr., R. W. Beck & Assocs., Box 117, Colorado Springs, Colo. (Jan. '51) *MPR*
- Indiana Glass Co.**, Derrill E. Shields, Asst. Plant Engr., Dunkirk, Ind. (Corp. M. Jan. '51) *MR*
- Jensen, Kenneth D.**, Supt., Water Dept., City Hall, Oswego, N.Y. (Jan. '51) *MP*
- Johnson, J. D.**, see Tennessee Gas Transmission Co.
- Johnson, James**, Water Comr., Yellville, Ark. (Jan. '51) *M*
- Jordan, Philip J.**, Engr., Water Safety, Control Section, 3300 E. Cheltenham Pl., Chicago 49, Ill. (Jan. '51)
- Kelley, G. Hartwell**, Owner & Operator, Magnesia Springs, Hawthorne, Fla. (Jan. '51) *P*
- Klingman, Fred W.**, Bacteriologist, Division Ave. Filtration Plant, W. 32nd & Division Ave., Cleveland 13, Ohio (Jan. '51)
- Kloer, Frank**, see Centlivre Brewing Co.
- Knowles, Virgil C.**, see Sidney (Neb.)
- Laubusch, Edmund J.**, Teaching Asst., San. Eng., Massachusetts Inst. of Technology, Cambridge 39, Mass. (Jr. M. Jan. '51) *P*
- Layton, Robert Jerome**, Engr., Water Dept., 646 Hemphill Ave., N.W., Atlanta, Ga. (Jan. '51)
- Lee, Robert D.**, Sales Engr., Denver Fire Clay Co., 2301 Blake, Denver, Colo. (Jan. '51) *P*
- Lentz, Grover T.**, Supt., Water Works, Hartsville, Tenn. (Jan. '51) *P*
- Livernois, Cameron J.**, Water Comr., Water Dept., 4373 High St., Ecorse, Mich. (Jan. '51)
- Lockwood & Andrews**, Cons. Engrs., Frank H. Newnam, Jr., 904 Union National Bank Bldg., Houston, Tex. (Corp. M. Jan. '51) *MR*
- Markus, William H.**, Solicitor & Secy., Munic. Authority of the Borough of West View, West View, Pa. (Jan. '51) *M*
- Marthinsen, John**, 653 Spring Garden St., Easton, Pa. (Jan. '51)
- McLarty, William J.**, Supervisor, San. Eng. Section, City Health Dept., 116 Temple St., Los Angeles 12, Calif. (Jan. '51) *P*
- Meng, Carl LeRoy**, Mgr., Glen Acres Water Co., 302 W. Montebello Ave., Phoenix, Ariz. (Jan. '51) *P*
- Merz, Robert C.**, Assoc. Prof. in Civil Eng., Univ. of Southern California, Los Angeles, Calif. (Jan. '51) *PR*
- Mijares, Gustavo Rivas**, Instituto Nacional de Obras Sanitarias, Div. Plantas Tratamiento, Edif. "Las Mercedes," Caracas, Venezuela (Jan. '51)

(Continued on page 34)

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(Continued from page 32)

- Miles Laboratories, Inc.**, Wendell C. Compton, Asst. Chief Engr., 1127 Myrtle St., Elkhart, Ind. (Corp. M. Jan. '51) *MPR*
- Moore, John M.**, Cons. Engr., 827 Knights of Pythias Bldg., Indianapolis, Ind. (Jan. '51)
- Moyer, Everett R.**, Assoc., M. B. Moyer, Cons. Engrs., 324 Pearl St., Syracuse, N.Y. (Jan. '51)
- Mullane, M. D.**, Manufacturers Agent, 339 Burgess Ave., Indianapolis 19, Ind. (Jan. '51)
- Napier, Charles E.**, 316 Russell Hill Rd., Toronto, Ont. (Jan. '51)
- Nelson, Theodore W.**, Research Director, Magnolia Petroleum Co., Box 900, Dallas, Tex. (Jan. '51) *PR*
- Newnam, Frank H., Jr.**, see Lockwood & Andrews
- Noble, John A.**, Tech. Sales Repr., H. L. Blackford Ltd., 22 College St., Toronto, Ont. (Jan. '51)
- Oliver, Bruce John**, Sales Engr., Tested Appliance Co., 2627 W. 19th St., Chicago 8, Ill. (Jan. '51) *P*
- Owen, William L.**, see William L. Owen Labs.
- William L. Owen Labs.**, William L. Owen, Cons. Bacteriologist, 2524 North Blvd., Baton Rouge, La. (Corp. M. Jan. '51) *P*
- Paine, Frank L.**, Supervisor of Procurement & Materials, East Bay Munic. Utility Dist., 2127 Adeline St., Oakland, Calif. (Jan. '51) *M*
- Pauszek, Felix H.**, Dist. Chemist, Quality of Water Branch, U.S. Geological Survey, Box 711, Raleigh, N.C. (Jan. '51)
- Poundstone, Art**, Supt., Water Dept., Rochester, Ind. (Jan. '51)
- Pyatt, Edward M., Jr.**, Chemist, Ball Bros. Co., Inc., Noblesville, Ind. (Jan. '51)
- Rankin, Robert L.**, Div. Mech. Engr., Shell Oil Co., 326 E. Broadway, Centuria, Ill. (Jan. '51) *P*
- Reinert, Donald F.**, Sr. San. Engr., Water Safety Control Section, 3300 E. Cheltenham Pl., Chicago 49, Ill. (Jan. '51)
- Riddle, W. G.**, Sr. Engr., Burns & McDonnell Eng. Co., Box 7088, Kansas City, Mo. (Jan. '51)
- Salter, George S.**, Engr., Filtration Design Section, Water Purification Div., 220 S. State St., Chicago 4, Ill. (Jan. '51) *MP*
- Sanders, Wilbur E.**, see Bendix Products Div.
- Seath, D. M.**, Mgr., Public Utilities Com., Irgersoll, Ont. (Jan. '51)
- Shapiro, Alvin Nelson**, Sales Engr., Alan A. Wood, Inc., Dupont Circle Bldg., Washington 6, D.C. (Jan. '51) *MP*
- Sheetz, Jack W.**, Asst. City Engr., 205 N. Greenleaf Ave., Whittier, Calif. (Jan. '51) *MR*
- Shields, Derrill E.**, see Indiana Glass Co.
- Sidney, City of**, Virgil C. Knowles, City Mgr., City Office Bldg., Box 79, Sidney, Neb. (Corp. M. Jan. '51)
- Smith, Milton T.**, Foreman of Distr., Water Dept., 402 City Hall, Tacoma, Wash. (Jan. '51) *MPR*
- Solberg, George Woodfield**, Asst. Water Chemist, Dept. of Water & Sewers, Miami, Fla. (Jr. M. Jan. '51) *P*
- Stock, John S.**, San Engr., Elkhart County Health Unit, Courthouse, Goshen, Ind. (Jan. '51) *P*
- Stokes, Herbert Raymond**, Partner, Rice, Stokes & Ferguson, Cons. Engrs., 412 Columbia Bldg., Pittsburgh, Pa. (Jan. '51) *PR*
- Sturm, Max Deland**, Regional San. Engr., State Board of Health, Box 210, Jacksonville 1, Fla. (Jan. '51)
- Tennessee Gas Transmission Co.**, J. D. Johnson, Sr. Results Engr., Box 2511, Houston, Tex. (Corp. M. Jan. '51)
- Terre Haute Brewing Co., Inc.**, Oscar Baur, Pres., 440 S. 9th, Terre Haute, Ind. (Corp. M. Jan. '51) *PR*
- Townsend, Albert Mac**, Supt. of Distr., Water Dept., Beaumont, Tex. (Jan. '51) *MPR*
- Tranel, Lester J.**, Chem. Engr., St. Louis County Water Co., 6600 Delmar Blvd., St. Louis 5, Mo. (Jan. '51) *P*
- Valdez, Rudolph L.**, Supt., Water Dept., Southwestern Public Service Co., Box 37, Guymon, Okla. (Jan. '51) *M*
- Walkwitz, Clarence Arthur**, City Engr. & Building Comr., City Hall, Wheaton, Ill. (Jan. '51) *MP*
- Watson, Edmund J.**, Instructor, Civ. Eng. Dept., Oregon State College, Corvallis, Ore. (Jan. '51) *PR*

(Continued on page 36)

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(Continued from page 34)

- Wolf, Morris L.**, Supt., Mech. Div., Bureau of Water, 306 City-County Bldg., Pittsburgh 19, Pa. (Jan. '51) *M*
- Wymbs, Norman E.**, Sales Engr., Johns-Manville Sales Corp., 1707 Oak St., Northbrook, Ill. (Jan. '51)

REINSTATEMENTS

- Campbell, R. C.**, Water Works Foreman, 1210 Hemphill Ave., N.W., Atlanta, Ga. (Apr. '48)
- Dunbar, T. J., Jr.**, Dunbar & Dickson, Cons. Engrs., Box 78, Freeport, Tex. (Jan. '46)
- George, Lloyd**, Sales Repr. Mueller Co., 5755 Wildwood, Indianapolis, Ind. (Apr. '40)
- Huffman, H. H.**, Supt., Water & Street Lighting Dept., Topeka, Kan. (Jan. '32)
- Indiana Girls School**, R.R. 2, Box 440, Indianapolis 44, Ind. (Corp. M. July '49)
- Lovejoy, William O.**, San. Engr., Florida Coca-Cola Bottling Co., 2334 Market St., Jacksonville, Fla. (July '43)
- McKay, R. Donald**, San. Engr., Dept. of Public Health, Provincial Bldg., Halifax, N.S. (Jan. '41)
- Ross, Charles A.**, Supt., Water Dept., Zanesville, Ohio (Apr. '43)
- Smith, Meloy**, 43 E. Main St., Rochester 14, N.Y. (Mar. '34)

LOSSES

Deaths

- Brewster, John H.**, Dist. San. Engr., State Dept. of Health, 412 Rogers Bldg., Glens Falls, N.Y. (Jan. '47) *P*
- Cobleigh, William Merriam**, Dean Emeritus of Eng., Montana State College, Bozeman, Mont. (May '33) *Fuller Award '41. P*
- Davis, Charles A.**, San. Engr., City & County of Denver, 372 City & County Bldg., Denver, Colo. (Oct. '43)
- Lord, Charles H.**, City Engr., Ogdensburg, N.Y. (June '29)
- Moore, W. D.**, 1534—7th Ave., W., Birmingham 4, Ala. (Jan. '38) *Fuller Award '42.*
- Vieno, R. R.**, Supt., Dist. Water Dept., City Hall, Beaumont, Tex. (July '38)
- Zapffe, Carl**, 325 Bluff Ave., Brainerd, Minn. (July '35) *P*

Resignations

- Crellin, Earle A.**, Asst. Engr. of Operation, Pacific Gas & Elec. Co., 245 Market St., San Francisco 6, Calif. (Jan. '46) *P*
- Garry, John J.**, Dist. Mgr., S. F. Bowser Co., Ltd., 64 Fraser, Toronto, Ont. (Jan. '48)
- George, William O.**, Geologist, U.S. Geological Survey, 302 W. 15th St., Austin 14, Tex. (Dec. '43)
- Jack, Allen**, Mgr., San Francisco Branch, Hersey Mfg. Co., 582 Market St., San Francisco 4, Calif. (Oct. '41) *M*
- Rochester Water Dept.**, Arthur Poundstone, Rochester, Ind. (Corp. M. Apr. '50) *MP*
- Skyrius, Walter M.**, Sales Repr., Johns-Manville Sales Corp., 819 Lincoln St., Waukegan, Ill. (Jan. '47)
- Talley, L. M.**, Asst. Street Supt., 120 Bonita St., Arcadia, Calif. (Oct. '48)

CHANGES IN ADDRESS

Changes received between January 5 and February 5, 1951

- Barbehenn, Ralph L.**, Tech. Director, Asbestos Cement Products Assn., 509 Madison Ave., New York 22, N.Y. (Apr. '45) *MPR*
- Beckman, Wallace J.**, Gannett Fleming Corddry & Carpenter, Inc., 46 N. 18th St., Harrisburg, Pa. (Apr. '47) *P*
- Benedict, Paul C.**, Regional Engr., Water Resources Div., Quality of Water Branch, U.S. Geological Survey, Lincoln, Neb. (Jan. '49)
- Bowman, Abraham M.**, 1631 Owen St., Preston, Ont. (Oct. '19) *Fuller Award '39. M*
- Buck, Ross W.**, San. Engr., Housing San. Div., Training Services, Communicable Disease Center, U.S. Public Health Service, 50—7th St., N.E., Atlanta, Ga. (Apr. '43) *P*
- Carroll, Thomas M.**, Mgr., Pump Dept., Fairbanks, Morse & Co., 4535 S. Soto St., Los Angeles 58, Calif. (July '49)
- Chandler, Harold C.**, 39 Niblock Court, Danker Village, Albany, N.Y. (Oct. '46) *P*
- Charles, Paul Lamont**, Sales Engr., Walsh & Charles Ltd., 408 Tribune Bldg., Winnipeg, Man. (July '47)

(Continued on page 38)

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(Continued from page 36)

- Churchill, J. W.**, Secy. & Office Mgr., Public Service Com., 601 Barrington St., Halifax, N.S. (Jan. '45) *M*
- Citizens Utilities Co. (Conn.)**, M. P. Griffith, Asst. to Vice-Pres., 125 E. Putnam Ave., Greenwich, Conn. (Corp. M. Apr. '47) *MPR*
- Clouser, L. H.**, Cons. Engr., Box 431, Knoxville, Tenn. (July '37) *MP*
- Cook, James R.**, Box 8861, Fernandez Juncos Station, Santurce, Puerto Rico (Jan. '37) *PR*
- Crachi, Domenico, Jr.**, Civil Engr., 233 Rockaway Ave., Brooklyn 33, N.Y. (Oct. '49) *R*
- Craig, Charles P.**, National Dairy Research Lab., Sayville, N.Y. (Jan. '42) *P*
- Dallach, W. A.**, 128 S. Madison Ave., LaGrange, Ill. (July '35)
- Day & Zimmerman, Inc.**, Theodore E. Seelye, Vice-Pres., 1700 Sansom St., Philadelphia 3, Pa. (Corp. M. Apr. '42)
- Ediger, Olin O.**, Ediger Eng. Co., Box 145, Wichita, Kan. (Jan. '47) *P*
- Eernisse, J. Guy**, Asst. Chief Engr., Water Div., Dept. of Public Utilities, 402 City Hall, Tacoma 2, Wash. (Apr. '39) *MP*
- Egan, James F.**, Box 1872, Fort Worth, Tex. (Jan. '46)
- Eller, Dwane L.**, Chief Operator, City Water Plant, 527 W. Elm, Junction City, Kan. (Apr. '50) *P*
- Evans, Paul J.**, Chief Chemist, U.S. Steel Co., Gary, W. Va. (Apr. '48) *MP*
- Faust, Raymond J.**, Exec. Asst. Secy., American Water Works Assn., 500—5th Ave., New York 18, N.Y. (Jan. '38) *Fuller Award '46. Goodell Prize '49. Director '50-'51. MPR*
- Gately, A. C.**, Mgr., Jackson County Public Water Supply, Dist. No. 1, Grandview, Mo. (Jan. '46)
- Gibson, William Charles**, School of Public Health, University of Michigan, Ann Arbor, Mich. (Jan. '49) *P*
- Goforth, D. C.**, Water Supt., Box 485, Strawn, Tex. (Jan. '49)
- Goldsmith, Clarence**, Pine Lodge, S. Main St., R.F.D. 1, Andover, Mass. (Dec. '15)
- Grantham, George R.**, Assoc. Prof. of San. Eng., Dept. of Civil Eng., Univ. of Florida, Gainesville, Fla. (Jan. '44) *PR*
- Great Falls, City of**, A. J. Richardson, Acting City Engr., Civic Center Bldg., Great Falls, Mont. (Corp. M. Jan. '25)
- Green, Stewart G.**, 13545—1st Ave., N.E., Seattle 55, Wash. (Apr. '47) *MPR*
- Griffith, M. P.**, see Citizens Utilities Co.
- Gustafson, J. P.**, Mgr., Lafayette Business Office, East Bay Munic. Utilities Dist., 3533 Mt. Diablo Blvd., Lafayette, Calif. (July '50)
- Guyton, William Franklin**, Cons. Ground Water Hydrologist, 10 Mississippi Ave., Silver Springs, Md. (Apr. '42) *R*
- Hammond, Robert H.**, Civil Engr., 2314 Glenada Ave., Montrose, Calif. (Oct. '48) *R*
- Hargleroad, James C.**, Ordnance Ammunition Center, Joliet Arsenal, Joliet, Ill. (Apr. '46) *P*
- Helbig, W. A.**, Chem. Engr., Darco Dept., Atlas Powder Co., 60 E. 42nd St., New York 17, N.Y. (Feb. '30) *P*
- Hendricks, Gerald F.**, San. Engr., 640 Union St., Columbus, Ind. (Jan. '46) *P*
- Hess, John S.**, 500 Hilltop Ave., Clearwater, Fla. (Oct. '42)
- Higgins, Frank T.**, Div. Engr., Water Dept., 403 Munic. Utilities Bldg., 215 W. Broadway, Long Beach 2, Calif. (Oct. '44) *MP*
- Holder, H. C.**, Trustee, City Water Works, 217 McGee Ave., Council Bluffs, Iowa (Jan. '46)
- Hopkins, Edwin W.**, 133 S. Allen St., Albany, N.Y. (Aug. '25)
- Illinois Inspection Bureau**, R. K. Phelps, 309 W. Jackson Blvd., Chicago 6, Ill. (Corp. M. Jan. '24)
- Irwin, Gifford Melville**, 1580 Despard Ave., Victoria, B.C. (Nov. '33) *MPR*
- Jewell, William V.**, 630 Bergen Ave., Jersey City 4, N.J. (Nov. '27) *M*
- Johnson, Dewey W.**, Research Engr., Cast Iron Pipe Research Assn., 122 S. Michigan Ave., Chicago 3, Ill. (Jan. '37)
- Johnston, Carl B.**, 1600 Royal Blvd., Glendale 7, Calif. (Jan. '46) *PR*
- Justice, Leon A.**, Chemist, Route 1, Jacksonville, N.C. (Apr. '46) *P*
- Kachorsky, Michael A.**, Borough Engr., Borough of Manville, Box 766, Manville, N.J. (June '39) *MPR*

(Continued on page 40)

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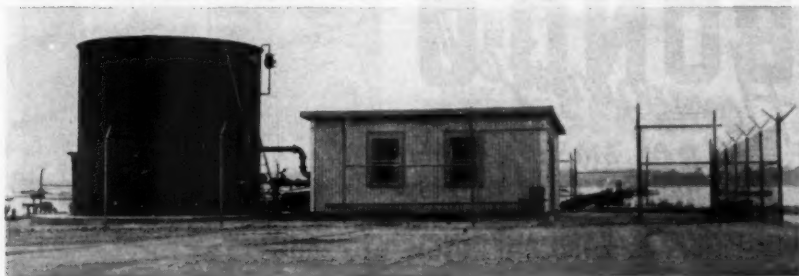
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(Continued from page 38)

Kingsbury, William Carter, Mech. Engr., 705 W. Granada Court, Ontario, Calif. (July '49) *MPR*

Kroeller, Louis E., Supervisor, Conduit Maint., Newark Water Dept., Grievess Terrace, Mountain View, N.J. (Oct. '47) *M*

Lawrence, Walter Byron, Project Engr., Cleaver-Brooks Co., 5100 N. 33rd St., Milwaukee 9, Wis. (Jan. '44) *PR*

Lewis, Robert F., 5626 N. Angeles Ave., San Gabriel, Calif. (Jan. '39) *M*

Leyenberger, Lawrence Alden, Civil Engr., Buck, Seifert & Jost, Box 8861, Fernandez Juncos Station, Santurce, Puerto Rico (Apr. '49)

Livingston, Vern, Mgr., Public Utilities, Nebraska City, Neb. (June '47)

Lordley, H. E., Asst. Director, Dept. of Public Utilities, 900 E. Broad St., Richmond, Va. (Jan. '36) *Director '49-'50. Fuller Award '50. P*

Macomber, Ronald Gibbs, U.S. Public Health Service, Region No. 4, 1100 Chester Ave., Cleveland, Ohio (Jan. '48) *PR*

McHugh, Arthur C., Valuation Engr., Bureau of Valuation & Research, 55 Elk, Albany, N.Y. (Jan. '44)

Minnesota & Ontario Paper Co., Richard J. Burrock, Chief Chemist, International Falls, Minn. (July '45)

Minor, Lynn O., Treas. & Mgr., Kankakee Water Co., 174 Schuyler Ave., Kankakee, Ill. (Jan. '22) *M*

Mitchell, A. C., Supt. of Eng., Dept. of Water Supply, 735 Randolph St., Detroit 26, Mich. (Jan. '38) *M*

Morgan, George, Vice-Pres. & Gen. Mgr., Victaulic Co. of Canada, Ltd., 406 Hopewell Ave., Toronto 10, Ont. (Jan. '41)

Oylear, Kenneth A., 10 Kentucky, Columbia, Mo. (Apr. '48)

Panesi, Richard C., Asst. Engr., Denver Board of Water Comrs., Route 2, Box 105, Littleton, Colo. (Jan. '50) *P*

Phelps, R. K., see Illinois Inspection Bureau

Potter, Walter, 41 Brookside Ave., Apt. 8A, Somerville, N.J. (Jan. '43)

Powers, O. C., Director & Medical Health Officer, Oxford County Health Unit, Woodstock, Ont. (Jan. '47)

Reinicker, L. T., Pres., American Water Works Service Co., Inc., 121 S. Broad St., Philadelphia 7, Pa. (June '29)

Richardson, A. J., see Great Falls (Mont.)

Robertson, D. A., Jr., State Water Control Board, 815 E. Franklin St., Richmond, Va. (Oct. '48)

Scobey, Fred C., Cons. Engr., 1063 Euclid Ave., Berkeley 8, Calif. (Jan. '32) *R*

Sennet, Lowell E., Sales Engr., A. P. Smith Mfg. Co., 8 S. Dearborn, Chicago 3, Ill. (Apr. '49)

Shapiro, Maurice A., Graduate School of Public Health, Univ. of Pittsburgh, Pittsburgh 13, Pa. (Oct. '43)

Smith, M. C., Chief Water & Research Engr., Dept. of Public Utilities, 900 E. Broad St., Richmond, Va. (May '25) *Director '37-'40. Fuller Award '40.*

Spector, Albert B., Lawyer, 714 Title & Trust Bldg., Phoenix, Ariz. (Jan. '48) *MPR*

Stanley, C. M., Cons. Engr., Stanley Eng. Co., Muscatine, Iowa (Sept. '32) *P*

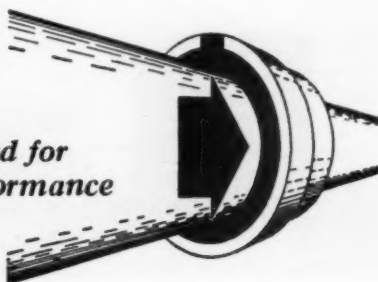
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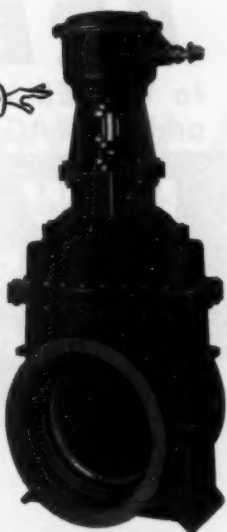
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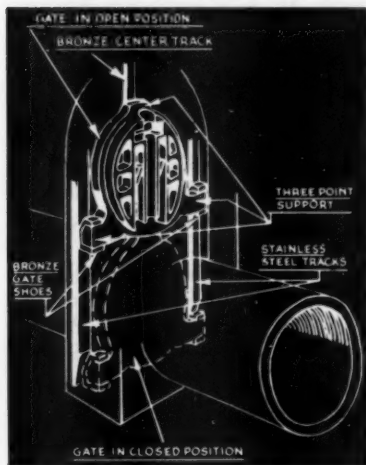


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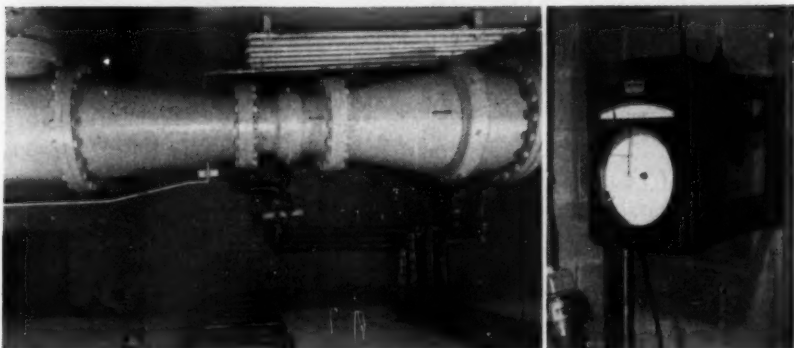
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(Continued from page 40)

- Stuart, Charles L.**, Admin. Asst. to Pres., Southern California Water Co., 950 Bendix Bldg., 1206 S. Maple Ave., Los Angeles 15, Calif. (Jan. '40) *M*
- Sundin, Hjalmar S.**, Instructor, Civ. Eng., Univ. of Illinois, Urbana, Ill. (Jan. '50) *PR*
- Svaty, Karl J.**, 902 E. Love St., Mexico, Mo. (Apr. '48) *MP*
- Svenkeson, S. K.**, Supt., Water & Sewers, Minot, N.D. (Oct. '44) *MP*
- Uline, B. A.**, 505 W. Market St., Nappanee, Ind. (Apr. '42)
- Van Gelder, John M.**, Dist. Mgr., Wallace & Tiernan Co., Inc., 1112 National City Bldg., Dallas 1, Tex. (Oct. '39)
- Vass, E. M.**, City Engr., Box 239, Fredericksburg, Va. (Jan. '47)
- Waddell, W. J.**, Western Repr., Neptune Meters Ltd., 617-7th Ave., E., Calgary, Alta. (Jan. '45)
- Waite, Robert F.**, 530 N. Taylor Ave., Oak Park, Ill. (Jan. '49) *P*
- Waterstraub, Lloyd C.**, City Manager's Office, Ironwood, Mich. (Oct. '49)
- Wauwatosa, City of, H. B. Wildschut**, City Engr., 7616 Harwood Ave., Wauwatosa 13, Wis. (Jan. '48) *M*
- Westcott, Ralph M.**, Cons. Engr., 1443 N. Alta Vista Blvd., Hollywood 46, Calif. (Apr. '50)
- Weston, Roy F.**, 9 Tyson Rd., Newtown Square, Pa. (July '37) *PR*
- Wheeler, W. W.**, Cons. Engr., Fell & Wheeler, 24 N. Elwood, Tulsa, Okla. (Jan. '37)
- Wintz, William R.**, 49 Willow Ave., Walnut Creek, Calif. (Oct. '40)
- Wise, William R.**, Supt. of Operations, Com. of Public Works, Greenwood, S.C. (Apr. '38)
- Wisely, W. H.**, Exec. Secy.-Editor, Federation of Sewage & Industrial Wastes Assns., 325 Illinois Bldg., Champaign, Ill. (Jan. '46)
- Wolfe, Thomas F.**, Managing Director, Cast Iron Pipe Research Assn., 1015 Peoples Gas Bldg., Chicago 3, Ill. (Mar. '22) *M*
- Yarabeck, Robert Roland**, 4545 Jefferson St., Apt. 306, Kansas City 2, Mo. (Oct. '47)
- Young, Francis D.**, Mgr., Pipe Section, Pittsburgh Dist., Johns-Manville Sales Corp., 610 Clark Bldg., Pittsburgh, Pa. (July '42)



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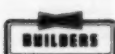
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Condensation

If the publication is pagged by the issue, 39:5:1 (May '47) indicates volume 39, page 473, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.*—*Bulletin of Hygiene (Great Britain)*; *C.A.*—*Chemical Abstracts*; *Corr.*—*Corrosion*; *I.M.*—*Institute of Metals (Great Britain)*; *P.H.E.A.*—*Public Health Engineering Abstracts*; *S.I.W.*—*Sewage and Industrial Wastes*; *W.P.R.*—*Water Pollution Research (Great Britain)*.

HEALTH AND HYGIENE

Tularemia in Man From a Domestic Rural Water Supply. W. L. JELLI-SON, DEANE C. EPLER, EDITH KUHN, and GLEN M. KOHLS. *Pub. Health Rpts.*, 65:38:1219 (Sept. 22, '50). Diagnosis of tularemia, with primary infections in tonsils and buccal mucosa, in a rural housewife and her sister-in-law suggested a common source of infection in contaminated food or water. The domestic water supply at one residence was shown to be contamnd. with *P. tularensis* in two consecutive tests. A survey of previous residents revealed that two of the housewives had experienced similar clinical illnesses and now gave positive agglutination reactions. Three others gave significantly positive agglutination tests but recalled no previous suggestive illness. Still another resident gave a low titer agglutination test of doubtful significance. Other individuals so far tested who were using, or had used, this same water showed no evidence of tularemia infection by serological test.—*B.H.*

Relation of Nitrate Nitrogen Concentration in Well Water to the Occurrence of Methemoglobinemia in Infants. KENNETH F. MAXCY. *U. S. Armed Forces Med. J.*, 1:1007 ('50). Geographical distribution of nitrate-contg. waters is reviewed. Water contg. nitrate N in excess of 10 ppm. should be considered unsafe for infant feeding. The nitrate concn. of water is, however, not the only

factor predisposing to methemoglobinemia.—*C.A.*

Infant Methemoglobinemia in Minnesota Due to Nitrates in Well Water. A. B. ROSENFELD & ROBERTA HUSTON. *Minnesota Med.* 33:787-96 ('50). A report of 146 cases including 14 deaths. Implicated water supplies had a nitrate-N content of more than 20 ppm.—*C.A.*

Mass Control of Dental Caries Through Fluoridation of Public Water Supply. H. TRENDLEY DEAN, FRANCIS A. ARNOLD JR., PHILIP JAY & JOHN W. KNUTSON. *U. S. Pub. Health Rpts.*, 65:1403 ('50). Anal. of 1949 dental exams. at Grand Rapids shows reduced amt. of dental caries experience when compared with the prefluoridation rates of 1944-45. Findings indicate that reduction is most pronounced in the younger age groups whose dentition was largely calcified following the addn. of 1 ppm. of F to the previously F-free public water supply. Sufficient time has not elapsed to evaluate water fluoridation in the older age groups.—*C.A.*

Methods and Costs of Water Fluoridation. F. A. BULL, T. A. HARD-GROVE & J. G. FRISCH. *J. Am. Dent. Assn.*, 42:1:29 (Jan. '51). Over 75 communities in Wis. adding or planning to add fluorides to water supplies. Experience in Wis. has shown: sodium fluoride is preferred in smaller communities using solution feeders; sodium silicofluoride cheapest source of

(Continued on page 46)

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(Continued from page 44)

fluoride ion but unsuitable in small communities because of excessively large solution tanks; hydrofluosilicic acid cannot be used undiluted in supplies pumping less than 250 gpm. because present feeders inaccurate at very low flow rates; fluoridation costs vary between 4¢/capita/yr. using sodium silicofluoride and 14¢ using sodium fluoride for a 1.2 ppm. fluoride dose; feeding equipment costs \$500 to several thousand depending on quantity of water treated; solution feeders more satisfactory for smaller communities primarily because caking of fluorides occurs in dry feeders.—F. J. Maier.

CHEMICAL ANALYSIS

Colorimetric Determination of Small Quantities of Aluminum in Water.

JOSE M. BACK & JUAN A. RAGGIO. Rev. Obras Sanit. Nacion 13:132:28 ('49). Results are described of a series of tests of Alizarin S method in detecting small quantities of Al in water. A series of tests also made, with varying known quantities of Al, to verify efficiency of hydroxylamine-HCl in reducing interfering ferric ion to the harmless ferrous ion. In the absence of Ca ion, hydroxylamine eliminates the ferric ion quantitatively, permitting detections at pH 4.0-4.1, the most sensitive range. The Ca ion increases the depth of coloration given by the Al-Alizarin lake, but also increases the ferric interference.—C.A.

Standard Methods of Water Analysis and Interpretation of Results.

G. E. MARTIN ET AL. Am. Ry. Eng. Assoc. Bul., 490:222 ('50). The Railroad Water Service Com. is recommending inclusion, in the A.R.E.A. Manual of Recommended Practice, of the Schwarzenbach method for determining Ca and Mg hardness in water with disodium ethylenediamine tetraacetate solution, one ml. equals one mg. as CaCO₃ with Eriochrome Black T

(Continued on page 48)

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(Continued from page 46)

for total hardness indicator and NH_4 purpurate for Ca.—C.A.

The Measurement of Suspended Matter in Water. J. SERPAUD. *Hidrol. Közlöny*, 29:42-4 ('49). Special app. has been constructed for sampling river water and detg. turbidity. The app. also makes possible an approx. detn. of the velocity of river flow.—C.A.

Comparison of Various Methods of Determination of Free Chlorine and Chloramines in Water. YU. YU. LUR'E & Z. V. NIKOLAEVA. *Zavodskaya Lab.*, 16:793 ('50). The iodometric, methyl orange, arsenite-tolidine, and *p*-amino-dimethylaniline methods give, with sufficient accuracy, the location of the inflection point on the curve of Cl absorption by water (in water purification techniques). The methyl orange method is recommended for this detn. The results of the detn. of Cl and chloramines by these methods are close but do show small deviations owing to instability of the system being analyzed. In the last two methods HNCl_2 causes part of the result to be calcd. as free Cl and part as chloramine. The methyl orange method gives a sharp differentiation between these two detns. Use of it along with the iodometric method permits accurate detn. of free Cl and total of chloramines.—C.A.

Determination of Organic Carbon in Natural Waters. V. G. DATSKO & V. E. DATSKO. *Doklady Akad. Nauk S.S.S.R.*, 73:337 ('50). Combustion of org. matter is done with molten KNO_3 at 400-50° by using the combustion tube technique. Oxidation of some CO and sublimates is done by means of CuO and Pt foil in a heated tube. Usual technique of tube method of combustion is followed with absorption trains. Air is used for conventional O

stream; it is purified by passage over CuO-Pt in a hot tube, followed by scrubbing with alk. The CO_2 from the sample is taken up in $\text{Ba}(\text{OH})_2$ soln. Techniques for handling moist sediments, etc., are discussed.—C.A.

Determination of the General Hardness of Natural Waters by the Blacher Method. O. A. ALEKIN & N. M. ANDREEVA. *Voprosy Gidrokhim.*, 32:40 ('46). A report of lab. studies of the conditions of the detn. of general hardness of water by the Blacher method. The Blacher method detns. only that hardness caused by the alkali earth metal. For natural waters, however, this is practically equiv. to the general hardness. The method of investigation consisted in accurate titration of artificial solns. having different contents of Ba^{++} , Ca^{++} , Mg^{++} and certain combinations of their mixts. For each salt, solns. of 0.02 *N* were prepd. and were suitably dild. as required. For the titrations, burets of 15-ml. capac. were used. They could be read to 0.01 ml. The titrations were carried out potentiometrically. The Compton electrometer system employed had a sensitivity of 10^{-12} amp. The app. was sensitive to a change of about 0.02 pH unit. Potassium palmitate was used as titrating agent. Since there was consumption of potassium palmitate caused by increasing pH up to the end point, corrections had to be applied in the titrations. For solns. with Ba^{++} , Ca^{++} , and $\text{Ca}^{++} + \text{Mg}^{++}$ this amounted to 0.12 ml. of the 0.1 *N* titrating soln., but for solns. with Mg^{++} it was only 0.05 ml. The sharpness of color given by phenolphthalein was impaired by potassium oleate, but not by potassium stearate or palmitate. For detn. of hardness above 2 mg.-equivs., the accuracy of the method was within the limits $\pm 1\%$. Only with less hardness, did it decrease to $\pm 2\%$. Electrometric curves are shown for: [1] titration of

(Continued on page 50)

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(Continued from page 48)

Ca^{++} and Mg^{++} soln. by potassium palmitate under different conditions of prepn. of sample, [2] titration of Mg^{++} soln. at different initial pH values, [3] titration of Ba^{++} solns. by different solns. of the potassium salts of fatty acids. Also there are curves showing the change of elec. cond. of distd. water as the CO_2 is removed from it by blowing air through it. A curve showing the hydrolysis of potassium palmitate by addn. of it to 100 ml. of distd. water with different contents of alc. and glycerol is provided. There are tabulated results for the detns. of hardness of water by the Blacher method.—C.A.

Determination of Lithium in Water by Flame Spectrophotometry.

JOHN T. CROSS. *Unpublished paper presented at meeting, Div. of Water, Sewage & San. Chem., Am. Chem. Soc. (Sep. 5-8, '50).* Lithium in water can be detd. rapidly by the Beckman flame spectrophotometer. Calibration curve is from 0.0 to 1.0 ppm. lithium. Instrument settings are: wavelength 668 $\text{m}\mu$, oxygen 18", air 20 psi., gas 2.0 cm., and slit width 0.70 mm. Diverse tons of sodium, potassium, magnesium, chloride and bicarbonate in amts. normally found in water do not interfere. Small quantities of calcium and strontium give erroneously high results. Author prepared a depressing agent of satd. $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$ to absorb the emission energies of calcium and strontium. Use of this agent allows concns. of 100 ppm. calcium and 10 ppm. to be present in the sample with minimal interference. The depressing agent is prepd. by satg. 100 ml. of distd. water with $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$, allowing the soln. to settle and filtering the supernatant through glass. To 25 ml. of sample, 1 ml. of this soln. is added and mixed by inversion in a 25-ml. glass-stoppered volumetric flask. Then 5 ml. of this soln. are placed in sample

cup under aspirating tube. With this technique, concns. of lithium as low as 0.1 ppm. can be readily detected.—P.H.E.A.

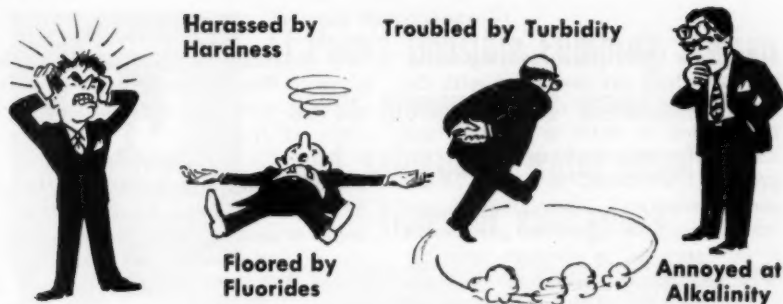
Phenoldisulfonic Acid Method of Determining Nitrate in Water.

MICHAEL J. TARAS. *Analytical Chemistry, 22:1020 (Aug. '50).* Optimum conditions for nitrate analysis include absence of chloride ion and presence of neutral or slightly alk. medium during sample evapn. Reproducible non-interference possible at nitrite nitrogen levels below 0.2 ppm. All reagent vols. must be equalized in both visual colorimetric standards and samples. Often use of ammonium hydroxide for color development obviates necessity for final filtration. Data suggest advisability of retaining the alk. normally present in most natural supplies as means of minimizing nitrogen losses attendant upon neutralization currently recommended in the phenoldisulfonic acid method of nitrate analysis. Need is also indicated for removing as much chloride ion as possible, because of natural incompatibility with nitrate in highly acid medium required for dominant reaction. Studies on synthetic and natural samples corroborate importance of losses occurring at low nitrate concns. in absence of these precautionary steps. Method is accurate to ± 0.01 ppm. on known nitrate concns. in region below 1.00 ppm. of nitrogen. Avg. reproducibility of 0.01 ppm. has been achieved on typical routine natural water samples in this lab.—P.H.E.A.

For Measurement of Radioactivity in Water and/or Sanitary and Industrial Wastes.

DOROTHY E. WALLACE, A. F. STEHNEY & H. GLADYS SWOPE. *Unpublished paper presented at meeting, Div. of Water, Sewage & San. Chem., Am. Chem. Soc. (Sept.*

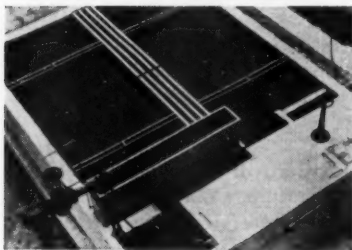
(Continued on page 52)



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(Continued from page 50)

5-8, '50). Units for measuring radioactivity which are concerned with the detmn. of amounts of radioactive materials found in water or sanitary and industrial wastes customarily expressed in fractional curie units (milli- and microcuries). Secondary consideration may be given to permissible levels expressed in roentgen units for beta and gamma radiation. 1. *Curie units.* The no. of disintegrations per unit of time for radioactive materials detn. the amt. in curies, and the detmn. of no. of disintegrations depends upon a number of factors. Type or types of activity being considered, alpha, beta or gamma radiation, detn. kind of counter to be used. Differentiation between emitters of various kinds of radiation shown by means of comparison of absorption in various materials, energies of radiation and specific activities. Methods for converting counts per minute as given by a particular counter into disintegrations per minute depend upon no. of factors which det. yields of counter. Brief discussion of the factors which det. yields of counters, and thus make possible the interpretation of radioactivity as disintegrations per minute, shows how such values are converted to curie or fractional curie amts. 2. *Comparison of normal levels* of radioactivity in fractional curie amounts with permissible levels for various types of radioactive materials, which might contam. water or san. and industrial wastes, shows the ranges allowable and how they vary in amount. Some different factors which cause such range variations are discussed. 3. *Roentgen units.* Specific examples showing calcns. by which beta and gamma emitters with known disintegration schemes can be converted into energy and thus into roentgen units are given. Levels of radioactivity which can be measured by survey instruments generally too high to be permitted in water or sani-

tary and industrial wastes. Example given to illustrate inadequacy of portable beta-gamma counter for such purposes.—P.H.E.A.

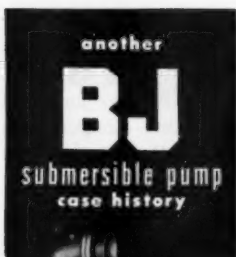
The Natural Radioactivity of Water.

S. K. LOVE. *Unpublished paper presented at meeting, Div. of Water, Sewage & San. Chem., Am. Chem. Soc. (Sept. 5-8, '50).* Radioactivity is a normal property of natural waters. Although sea water would be expected to contain relatively large amts. of radium, it has been found that it contains approx. 0.08×10^{-12} g. of radium/l., which is only $\frac{1}{4}$ of the amt. required for equilibrium with the quantity of uranium present. Ocean-bottom sediments, on the other hand, contain an excess of radium required for equilibrium with uranium. Several mechanisms have been proposed to account for radium deficiency in sea water and excess in bottom sediments. Radioactivity of spring waters has been detd. for a large number of springs all over the world, especially in those areas where spas and health resorts have been developed. Thermal springs usually contain more radium than cold springs. Radioactivity of most spring waters is less than $10,000 \times 10^{-12}$ g. of radium/l., although values in excess of $500,000 \times 10^{-12}$ g./l. have been published.—P.H.E.A.

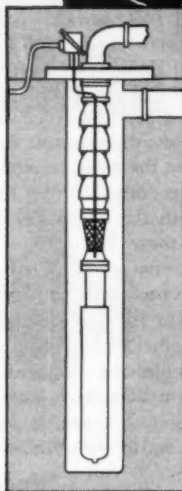
Estimation of Radioactive Strontium, Barium, Cobalt, and Iodine in River Water.

J. F. DUNCAN, T. F. JOHNS, K. D. B. JOHNSON, H. A. C. MCKAY, W. R. E. MATON, E. W. A. PIKE & G. N. WALTON. *J. Soc. Chem. Ind., 69:25 ('50).* Methods involving chem. sepn. followed by β -ray counting were developed for concns. down to 10^{-10} curie/l. For Sr and Ba the usual chromate method is employed for chem. sepn., the elements then being pptd. as carbonates for counting. For Co the water sample is evapd.

(Continued on page 54)



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(Continued from page 52)

down with HNO_3 . Ammonium cobalthiocyanate is extd. with a mixed amyl alc.-ether solvent and the Co is pptd. as ferrocyanide for counting. The I is extd. from the water sample by CCl_4 and pptd. as AgI for counting. A cylindrical counter having a 7-mg./sq. cm. end-window was used for most of the counting, but for Co^{60} a 4-mg./sq. cm. window is recommended.—C.A.

BACTERIOLOGY

The Public Health Use of the Catalase Reaction. O. SPITTA. Z. Immunitäts., 107:23 ('50). The purity of drinking water is detd. by its catalase content. A sample of water is mixed with 0.1 its vol. of H_2O_2 and melted gelatin is added. Either 0.25 or 0.5 ml. of the mixt. is placed in a depression of a glass slide and the gelatin is allowed to solidify. The amt. of catalase is detd. by the no. of bubbles formed. The catalase content is proportional to the no. of bacteria in the water. In a like manner, dust from the air gathered in water is measured for its catalase content.—C.A.

Literature Review on the Occurrence and Survival of Enteric, Pathogenic, and Relative Organisms in Soil, Water, Sewage, and Sludges and on Vegetation. 1. Bacterial and Virus Diseases. W. RUDOLFS, L. L. FALK & R. A. RAGOTZKIE. Sew. & Ind. Wastes, 22:1261 (Oct. '50). The following general points have been brought out by the literature survey presented: [1] Raw fruits and vegetables growing in infected soil can be contaminated with pathogenic bacteria. [2] Such infected vegetation may be difficult to clean and disinfect, especially if parts are injured or broken. [3] Among factors influencing survival of intestinal pathogenic bacteria in soil and on vegetation are following: (a) type of organisms—*Esch.*

coli, *E. typhosa*, and *M. tuberculosis* appear to be most resistant; (b) temperature—lower temperature increases viability; (c) moisture—longevity is greater in moist soil than in dry soil; (d) type of soil—neutral, high-moisture-holding soils favor longevity; (e) organic matter—the type and amount of organic matter present may serve as a food and energy source to sustain or allow bacteria to increase; (f) the presence of other microorganisms has an influence on the pathogenic organisms. This has been illustrated repeatedly by longer survival after inoculation of a pathogen into a sterilized soil, sewage, or water than into a corresponding non-sterile substrate. [4] Among the most common intestinal-disease and nonpathogenic bacteria, *Eberthella typhosa*, *Mycobacterium tuberculosis* and *Esch. coli* appear to be the most resistant to natural conditions outside the human body. Also, with the exception of *M. tuberculosis*, these have been studied the most extensively. Furthermore, the methods for isolating *Esch. coli* and *E. typhosa* in soil, sewage, and water have reached higher development. [5] As a whole, the literature leaves the impression that *Esch. coli* is more resistant than *E. typhosa* in soils, sewage, and water.—P.H.E.A.

Survival of Bacteria in High pH Waters. M. H. RIEHL, H. H. WEISER & B. T. RHEINS. Unpublished paper presented at meeting, Div. of Water, Sewage & San. Chem., Am. Chem. Soc. (Sept. 5-8, '50). To establish more definitely the sterilizing effect of lime softening of water, this research program inaugurated in July 1948 under National Institutes of Health grant, under the admin. of Ohio State Univ. Research Foundation, with the Ohio Dept. of Health Labs. cooperating. Various specific organisms, both pathogenic and non-

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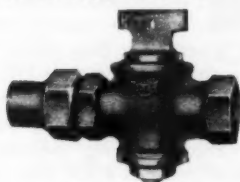
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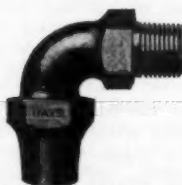
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pathogenic, of the water-borne type, were selected for the study, using both stock strains and freshly isolated cultures. The pH values in the range encountered in lime softening of water were used, and temperatures were selected to correspond to the most adverse conditions normally encountered in both surface and ground supplies. Natural waters, previously rendered sterile by chlorine, were brought to temperature by overnight storage in thermostatically controlled cabinets, dechlorinated with sterile thiosulfate, then inoculated with a sufficient quantity of a specific culture to provide an original count of about 1000 organisms/ml. Predetermined dosages of alum, soda ash and lime, in the quantities needed to coagulate, soften, and also adjust the pH value, were then added. Plating for residual bacteria count started almost immediately with the mixing and subsequent sedimentation operation, and the plating continued over a sufficient time either to establish the time for complete kill or to determine a rate of kill. Temperature was maintained by keeping sample in the cabinets during the entire period. Data obtained show that [1] the organisms were killed less rapidly at lower temperatures; [2] the rate of kill increases greatly at higher pH values; [3] rate of kill was not seriously affected by type of water, except as to the mechanical removal of organisms due to the larger quantities of floc produced, which means the apparent rate was greater for highly turbid water or water high in hardness; [4] stock strains of organisms were generally much easier to kill than freshly isolated cultures; and [5] pH values of 11.0 to 11.5 were usually needed to produce effective results at normal plant detention times of 4 hours. Organisms studied to date include stock and freshly isolated *Escherichia coli*, *Aer. aerogenes*, *Streptococcus*

(Continued on page 60)

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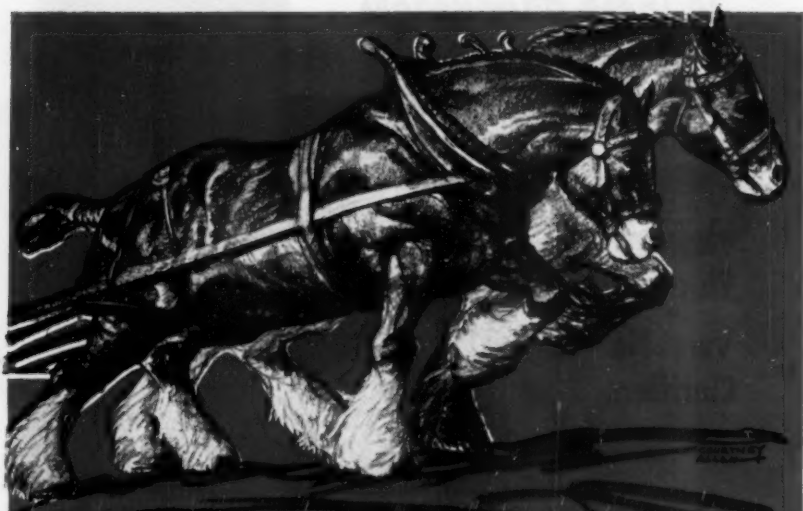


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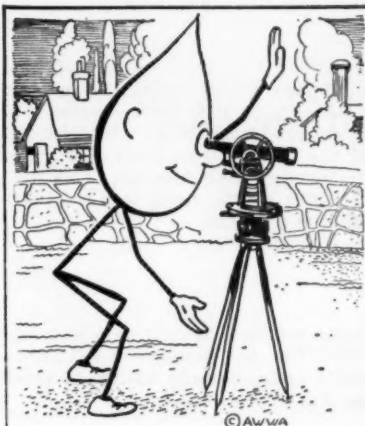
fecalis and *Salmonella typhi*, and freshly isolated *Salmonella montevideo*.—P.H.E.A.

Rapid Detection of *Esch. coli* in Drinking Water with Fecal Pollution. GERTRUD MULLER. Zent. f. Bakt. I. Abt. Orig., 153:6/7:237 (Mar. 25, '49). Author set out to devise method by which presence of fecal coli in drinking water could be detected within single working day. Method adopted was filtration of water through membrane filters, culture of the filters in tryptic digest broth, and testing of the broth at intervals for a positive indole reaction. In preliminary expts., graded dilns. of *Esch. coli* culture in main water filtered through membrane and filters cultured in digest

broth. Time required for indole reaction to become positive varied with initial inoculum and ranged from 2 hr. for 180,000 organisms to 24 hr. with an inoculum of 14 organisms. A series of 30 water samples then examined by broth culture of filters representing 1,000-ml. vols., and by direct culture on Endo's medium of membranes through which 100-ml. vols. had been filtered. Found that, provided *Esch. coli* count was at least 10 per ml., a positive indole reaction was obtained within 7-8 hr., and reaction became positive in 6 hr. if counts were over 100 per 100 ml.—B.H.

A description of the Methods used in the Institute of Hygiene of Göttingen University for the Detection of *Esch. coli* in Drinking Water by

(Continued on page 62)

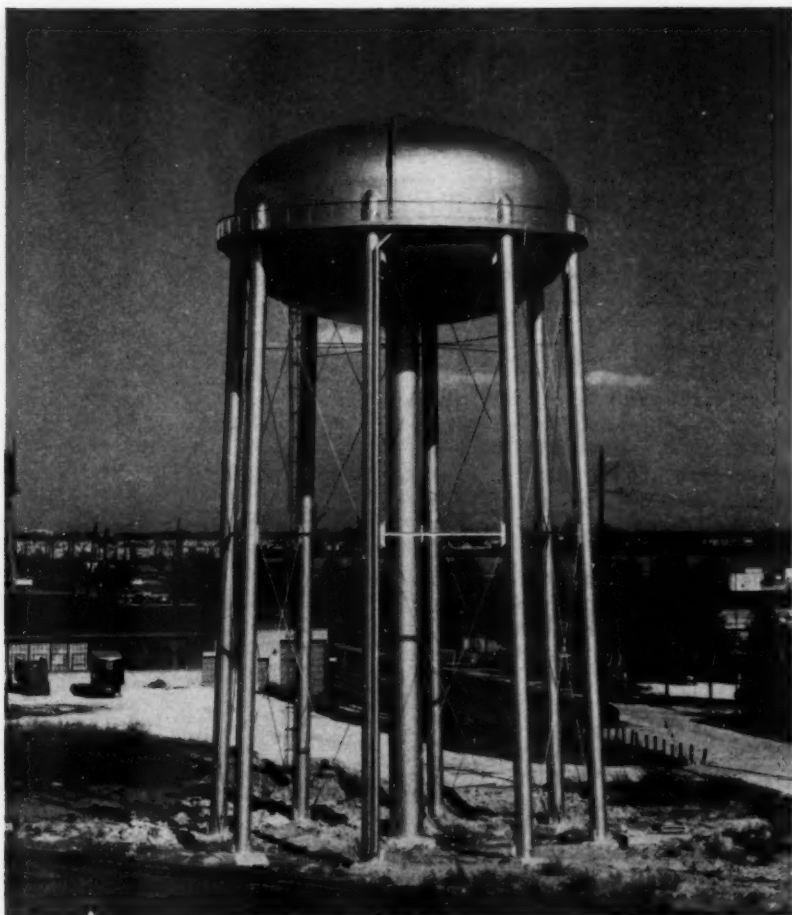


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LOS ANGELES

(Continued from page 60)

the Use of Membrane Filters. H. KRUSE. Zent. f. Bakt. I. Abt. Orig., 153:6/7:241 (Mar. 25, '49). Author describes method for detection of fecal *Esch. coli* in water based on principle of filtering suitable vol. of the test sample and then culturing filter in appropriate media. Special membrane filters used could be either spread on surface of solid media or immersed in fluid enrichment medium. With former method, found that Endo's medium incubated at 41°C. gave practically pure cultures of fecal *Esch. coli*. Fluid enrichments were done in Bulir's mannitol-neutral-red infusion broth at 46°C. *Esch. coli* of fecal type gave good growth under these conditions, with abundant gas production and greenish fluorescence.—B.H.

The Bactericidal Effect of Ammonia-Chlorine Treatment, Residual Chloramine and Free Residual Chlorine.

R. C. HOATHER. J. Inst. Wtr. Engrs. (Br.) 3:507 (Sept. '49). Recent research in U.S. on rate of bactericidal action of chlorine and chloramine has shown that preformed chloramine is very much slower in action than free chlorine. It is unusual to apply preformed chloramine for the purif. of water supplies; the method of applying ammonia and chlorine usually adopted is the ammonia-chlorine process in which chlorine is added to the water after the application of ammonia, or the native ammonia in the water is utilized for the purpose, if sufficient. Combination of ammonia with chlorine is not immediate but depends upon the concn. of reactants and is slower at low temperatures. Thus there is opportunity for free chlorine to exert its rapid bactericidal action before combining with ammonia. Expts. described by author confirm that rate of destruction of bacteria is much faster by the ammonia-chlorine method than by preformed chloramine,

and that the former more nearly approaches the rate achieved by free chlorine, particularly at low temperatures, such as 7°C. "In these experiments it has been found that when chlorine is added to water containing ammonia, its bactericidal action is at first extremely rapid. If the number of bacteria is large, however, a small proportion of them survive this initial phase of rapid action and are then subject to destruction at a slow rate. This progressive retardation in rate is doubtless due to the formation of chloramines, the bactericidal action of which is of the order of 100 times slower than that of free chlorine. A study of the kinetics of the reaction would be of interest, but it can be assumed that the rate of formation of chloramines (in common with most other chemical reactions) is a positive function of the temperature of the water and the concn. of both reactants, i.e. the ammonia and the chlorine. The difference between *ammonia-chlorine treatment* and *free residual chlorination* is thus less marked at 7°C. than at 18°C., because the lower temperature allows free chlorine to be present for a longer time before combining completely with ammonia. Similarly, the adverse effect of an increasing amount of ammonia is explained by the resulting increase in the rate of formation of chloramines. . . ."

—B.H.

ANNUAL REPORTS

Kenosha (Wis.) Water Dept. Annual Report (1949). Supply from L. Michigan. Pop. 56,000. New 24" transmission main through Simmons Island Park to insure continuity of supply from plant in event of break in either or both of underwater harbor transmission mains. For second time, wood crib around five 42" intake riser pipes lost. Replaced by 7"-diam. steel drums, and concrete riprap placed

(Continued on page 64)



For repairing bell and spigot joint leaks

In the **SKINNER-SEAL**
Bell Joint Clamp,
gasket is completely
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tected by Monel Metal
Band. Massive $\frac{3}{4}$ "
high-tensile steel bolts,
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This speedy one-man
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SKINNER-SEAL BELL JOINT CLAMP

(Continued from page 62)

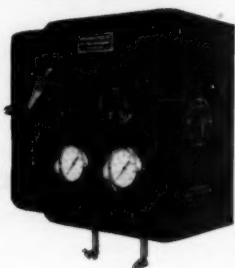
around intake area. No ice troubles, although difficulties experienced in neighboring intakes. Customers' meters accounted for 90% pumped, 4.4% increase. Addnl. 2.5% accounted for by known unmetered use. Meters in use 12,240, 45% new or recently tested. Avg. consumption 7.46 mgd. (133.3 gpcd.), 4.2% decrease. Operating revenue \$376,787 (\$6.73 per capita), increase of 17.1% (rates increased May 1). Operating expenses \$324,934 (including depn. \$37,815), increase of 11.8%, half due to extraordinary maintenance. Operating expenses, excluding fixed charges, depn. and taxes \$85.87 per mil.gal. Real estate tax \$53,291, 14.1% of revenue. City, by order of Public Service Commission (Apr. '49), must pay water dept. for fire protection \$90,000 annually plus

fixed amt. for new hydrants and footage of mains added during yr. Net income \$54,146, surplus to date \$2,182,978, fixed assets \$2,557,161, bonds outstanding \$360,000, depn. reserve \$648,707. Avg. cost to residential consumers 11.94¢ per 100 cu.ft. (3.5¢ per customer per day), commercial 8.97¢, industrial 5.31¢. Avg. evapn. per lb. of coal 8.91 lb., overall boiler and furnace efficiency 75.6%, avg. steam cost 41¢ per 1000 lb. Mains 129.7 mi., hydrants 1068 (8.2 per mi. of pipe), valves 1530. Personnel: 1 per 1275 persons served. Pop. per mi. of mains 428, services 13,570. Main constr. costs per ft.: 6" \$2.93, 8" \$3.62, 24" \$18.70. Wash water 3.3%, avg. alum dosage 0.66 gpg.; turbidity reduced from 24 ppm. to 0, final pH 7.5, residual Cl 0.38 ppm.—R. E. Thompson.

(Continued on page 66)

If you are buying a new zeolite water softener or sand filter or modernizing existing equipment make sure it's equipped with an

H & T POPPET TYPE MULTIPORT VALVE



It's built in 4 standard sizes for both sodium cycle and demineralizer units, sand and anthracite filters and for manual, semi-automatic and fully automatic operation.

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U. S. A.

A city selects "Century" Asbestos-Cement Pipe after "in use" tests

Before you buy or specify any pipe for water mains, consider the experience of a large city in the southwest:

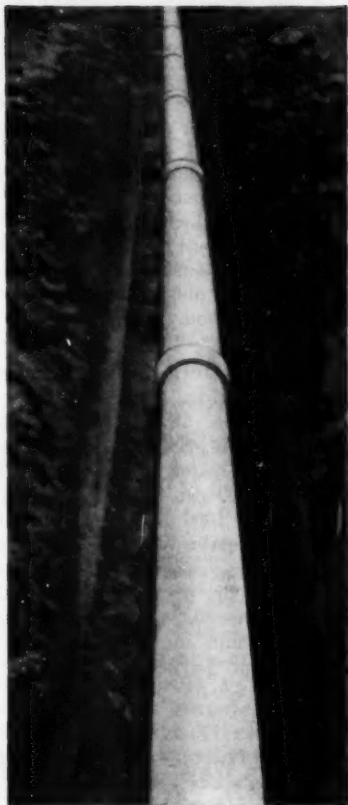
Because of deterioration from electrolysis and lowered efficiency from tuberculation, original installations of pipe needed replacement after only six years' service. Special test installations of "Century" Asbestos-Cement Pipe—supervised by city water officials—proved: "Century" Pipe is not affected by tuberculation; it resists both electrolysis and soil corrosion. Result: Many thousands of feet of Asbestos-Cement Pipe have been laid under the streets of this city and its suburbs as replacements and extensions for the system.

Consider also the other features of "Century" Pipe: It's exceptionally strong, yet light in weight; can be handled easily, laid quickly without special laying equipment. "Century" Simplex Couplings permit rapid, easy laying of both straight runs and curves up to 5° deflection per pipe length. And "Century" Pipe can be recovered and relaid in its original pressure class!

If you have difficult or unusual conditions that may affect the service of your water mains, get complete information on Keasbey & Mattison "Century" Asbestos-Cement Pipe. We'll gladly send details upon request.

Nature made Asbestos...

Keasbey & Mattison has made it serve mankind since 1873



"Century" Pipe is made in two pressure classes: 100 and 150 pounds per square inch. Every section is hydrostatically tested to insure ample reserve to handle normal "water hammer" and possible pressure increases.

"Century" Pipe is made in accordance with and conforms to U. S. Federal Specifications S5-P-351, which recognizes this pipe as suitable for purchase by all U. S. Government agencies.



KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

(Continued from page 64)

Ottawa (Ont.) Annual Report (1949). Supply from Ottawa R., filtered and chlorinated. Consumption 23.4 mgd., 121 gpcd. Pressure 75-85 psi. Pop. served 193,496, of which 162,442 in city. Mains 273 mi., valves 2802, services 37,277, meters 3717, hydrants 2361. Rate of filtration 69.6 mgd., wash water 1.85% of water filtered, avg. filter run 65.5 hr. (max. and min. 128 and 29, resp.). Chem. dosages and cost per mil.gal.: alum 2.37 gpg., \$4.81; lime 0.88 gpg., 79¢; Cl 19.1 lb. per mil.gal., \$1.84. Revenue \$1,297,706. Of 3141 samples of city water examd., only 1 unsatisfactory.—*R. E. Thompson.*

Stratford (Ont.) Annual Report (1949). Supply from wells, chlorinated. Pop. 18,823. Consumption 2.8 mgd., 125 gpcd. Storage: ground 2 mil.gal., elevated 0.5. Revenue \$71,489, per 1000 gal. 8.34¢; expenditures \$66,116, per 1000 gal. 7.71¢. Pressure 65-70 psi., mains 46 mi. (13' per person served), services 4958 (95.5% metered), pop. per service 3.8, valves 74, hydrants 302. Rates 4.5-15¢ per 100 cu.ft., min. mo. bill. 50¢, discount for prompt payment 10%. Assets \$689,536, \$36.63 per capita.—*R. E. Thompson.*

Singapore Water Dept. Annual Report (1942). Report, first issued since war, divided into 2 parts: first part for period Jan. 1-Feb. 15, '42, and second Feb. 16-Dec. 31, '42, i.e., after Japanese occupation. Report to Japanese by P. C. Marcus after internment of D. J. Murnane, Munic. Water Engr., included. This report states that airraid occurred on Dec. 8, '41, day war declared, minor damage being done to mains. Mains chlorinated and tested before restoration to service wherever damaged. Supply works unaffected until Jan. 17, when 3 breaks caused in 39" steel Gunong Pulau pipe-

line—in 1 break five 20' lengths displaced, repairs being completed in 2.5 days. Other damage included destruction of pumping sta. roof, demolition of superintendent's house and direct hits on slow sand filters. On Jan. 31, Johore Works and Gunong Pulau pipeline out of commission by destruction of causeway and lock, leaving only island resources. Supply adequate until capitulation—no complete interruption at any time. Normal supplies restored about Mar. 15 and damage to mains repaired by May 4. Main breaks totaled 150. From beginning of yr. consumption far below normal as supply discontinued to all domestic premises not served by sewer system. Standpipes erected to serve min. needs. In '41, consumption 27 mgd.; during Jan. 1-Feb. 15, under 20 mgd. Reservoir areas at times main battleground. Filters out of commission eventually but chlorination uninterrupted. During Jan., avg. bacterial count (agar) on tap water 62 per ml. and only 3.3% of samples contained lactose fermenters in 100 ml. Staff casualties: killed 12, injured 3. In addn., more than 10 failed to return from internment camps. Japanese in nominal control Feb. 16. Repairs proceeded with immediately with aid of Royal Engineers and Japanese military labor. Plant improvised from local materials to manufacture Cl for treatment during occupation. Municipal water engineer interned July 10. Constant supply of pure water maintained throughout occupation period.—*R. E. Thompson.*

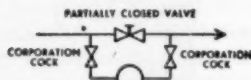
MISCELLANEOUS

Water Treatment for Cooling Towers. JOHN B. DAVIS. Heating, Piping, & Air Cond., 22:4:89 ('50). Surface-active agents, including metaphosphate, pyrophosphate, tetraphosphate and triphosphate, are effective in

(Continued on page 68)

CHLORINE DIOXIDE TREATMENT

**A PAINLESS CURE
for a Sick
Water Works**



For use in by-pass around partially closed gate valve acting as a variable orifice to maintain a disinfecting residual while main is in use.

Discovery of contamination in the mains was mighty disturbing to a certain New England town of 15,000 people, extremely proud of its pure water supply. But the cure was simple and sure — %Proportioneers% Chlorine Dioxide System in ten days entirely eliminated the contamination while the mains were in use. In addition, the chlorine dioxide "saved face" for the water works since the treatment was completed virtually unbeknown to the water users.

TREATMENT: %Proportioneers% hydraulically operated Chem-O-Feeder, complete with Chlorine Dioxide Generator, was easily installed as shown in the diagram. No elec-

tricity or other outside power was required. A residual of 1 ppm as measured with O. T. was established in the mains and gave an actual residual of 2.5 ppm Cl and ClO₂ — without noticeable taste or odor. After 10 days, tests proved the sterilization complete, and the treatment was discontinued.

TODAY, in peace or war, pure water is a "must"! Every water works needs this emergency sterilization equipment. %Proportioneers% Chlorine Dioxide System is the ideal unit . . . it's complete, ready for instant use: to sterilize new mains, to eliminate contamination, to meet the emergencies of war. Investigate now, while equipment is still available. Write for bulletins.

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(Continued from page 66)

preventing pptn. of CaCO_3 . Sodium pentachlorophenate in dosage of 20-30 ppm. is effective in preventing biol. growths. One advantage over Cl_2 is that none of it is dissipated in aeration tower.—C.A.

Experiences With Vertical and Horizontal Wells at Zürich, Switzerland. E. BOSSHARD. Monatsbulletin Schweiz Gas und Wasser, 30:4:84 (Apr. '50); 30:5:112 (May '50). Zürich has ground water supply in diluvial sands and gravel, consisting of 11 gravel-packed wells and Ranney well. The gravel-packed wells, 170' to 270' apart, are 92' deep with 20" screens 40-54' long. Special tests run on yield through the different depths of screen and with part of screen blocked off; temperatures measured at all depths. Considerable vert. movement discovered in aquifer near screen. Wells produced total of 14.8-16.8 mgd. For addl. water, Ranney well built 550' from nearest vert. well. It yields 2.5 mgd. and has 6 horiz. screens 37-155' long—total 210'—and 27' vert. screen in center. Each screen tested separately for yield, temperature and water qual. Two screens sealed off as water they furnished too turbid. Surprisingly, yield of all screens together only 25.7-30% of the total of the individual yields.—Max Suter.

On the Question of the Action in Rapid Filters. H. GROMBACH. Monatsbulletin Schweiz Gas und Wasser, 30:11:297 (Nov. '50). Two theories attempt explanation of action of rapid sand filters: [1] filtering only in surface layer; and [2] filtering throughout depth of sand. To check action, filter collectors were installed at 10" intervals of depth and valved in pipe gallery, where samples were collected from continuous flow. Series taken during invasion of threadlike oscillatoria, and 2.5 l. of sample filtered

through a porcelain filter. Filter washed with 25 ml. clear water and concentrate microphotographed on plankton cell 1 hr. after filter put in operation and then every 3 hr. until 21 hr. had passed. Illustrations show progressive penetration of oscillatoria; at first only broken pieces pass, apparently at a velocity 1 to 2% of water velocity. About 50% retained in top 6" of filter, but without blocking passage of others. After 21 hr. the whole depth of 4'8" of sand contained full length oscillatoria, confirming the whole-depth-action theory, at least for oscillatoria. No tests made for other organisms.—Max Suter.

Methods of Water Treatment for Carbonated Beverage Use. C. VANDERMOLE & H. B. GISTAFSON. Unpublished paper presented at meeting, Div. of Water, Sewage & San. Chem., Am. Chem. Soc. (Sept. 5-8, '50). Carbonated beverage industry has grown considerably in past 20 years, during which practice of treating beverage water has become universal. Prior to 1925, the greatest concern was to produce a beverage free of noticeable foreign particles and of good appearance. Filters of all types were used to accomplish this end. Results were considered satisfactory on the basis of standards of that time. Increased interest in activated carbons and their use in water treatment developed subsequent to 1925. Advantage of such treatment for beverage water was obvious, and carbon purifiers became quite general in beverage plants. Next development produced equipment for coagulation and sterilization to remove objectionable organic matter. A few years later, importance of chem. characteristics of water affecting the uniform taste of finished beverage was realized, and equipment for alky. reduction was developed. Both lime treating plants and acid zeolites have

(Continued on page 70)

ARMCO STEEL PIPE

MEETS JOB REQUIREMENTS TO SAVE METAL AND MONEY



Because Armco Welded Steel Water Pipe comes in a wide range of diameters (6" to 36") with wall thicknesses from 9/64- to 1/2-inch, you can match exact job requirements. You buy no excess metal. Write for complete information. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 2171 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation.

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One of the lessons of the postwar period was the disclosure that many water works need to consider seriously a major job of face-lifting on their accounting systems. Faced with the fact of inflation, many an executive has found his financial records inadequate to provide the data and analyses needed to guide him in his current policies and practices.

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Works Association**

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New York 18, N. Y.

(Continued from page 68)

been used, but generally lime treatment has prevailed. Formerly distn. was only method of reducing dissolved solids content of few supplies considered above the accepted limits. Development of cation and anion exchangers has overcome objections to stills, and exchangers usually employed where such treatment is required. In minority is such equipment as ultraviolet ray, ozonators, and various "electric water purifiers."—P.H.E.A.

Removal of Radioactive Isotopes From Water by a Phosphate Coagulation and Flocculation Process.

R. A. LAUNDERDALE. *Unpublished paper presented at meeting, Div. of Water, Sewage & San. Chem., Am. Chem. Soc. (Sept. 5-8, '50).* Health Physics Div. of Oak Ridge National Lab. is interested in the treatment of liquid wastes, particularly those with low levels of radioactivity, and in the effectiveness of conventional active isotopes. One prin. method of treatment of wastes is by coagulation, flocculation, sedimentation and filtration. Lab. work done on a selected no. of isotopes, using a calcium phosphate floc as coagulating agent. Data obtained on the removal of isotopes of Sr, Y, Ce, Zr, Nb, Zn, and Sb from disd. water. Floc formed by mixing solns. of calcium hydroxide and either potassium dihydrogen phosphate or trisodium phosphate. Efficiencies of removal calcd. from data collected by measuring the count in the water before and following treatment. Found that concn. of activity in floc depends on at least 3 variables: quant. of floc, the pH, and ratio of phosphate to calcium. The paper includes discussion of advantages of flocculation as treatment process and the presentation of data on the efficiency of removal of various isotopes. Effects of the different variables are illustrated.—P.H.E.A.

(Continued on page 72)



WW-14

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Authority

To meet increasing water requirements, the Chester Municipal Water Authority has established a new intake and filtration plant at Oxford, Pa., equipped with eight new De Laval pumps having a total capacity of 36 mgd.

*80% of all large cities in this country use De Laval pumps.

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DE LAVAL



(Continued from page 70)

Rural Water Supplies. PETER LAMONT. *Wtr. & Wtr. Eng. (Br.)*, 54:19 (July '50). Development of rural supplies began in earnest after cholera epidemics which first occurred in 1830. Inevitable that rural supplies should lag behind those of cities; in 1914 less than $\frac{1}{3}$ of pop. in 70% of parishes received piped water supply. In '20's development very slow; encouraged by Local Govt. Act of '29, but not begun in earnest until financial inducements offered. Start made in '29 with Development Act, under which grants made toward cost of rural supplies as measures of unemployment relief. Followed by Rural Water Supplies Act of '34, under which £1,000,000 in govt. grants made for rural supplies. Estd. that 7,754 parishes supplied in '39 contained at least 80% of total

rural pop. General progress on rural supplies interrupted by World War II. Development again encouraged by Rural Water Supplies and Sewerage Act of '44 under which govt. set aside £15,000,000 for rural water and sewerage schemes in England and Wales. At present, rural parishes may derive piped supplies from purely local sources, but more usually they either form part of statutory area of supply of water authority or receive metered supply in bulk from water authority. Rural dist. councils vary widely in area and pop.; avg. pop. approx. 17,000 spread over 122 sq.mi. Ideal size for rural water works is smallest area in which possible to employ qualified staff and provide building, stores, transport and equipment to operate, maint., and develop undertaking and give reason-

(Continued on page 74)

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were plaguing the city of Clear Lake, Iowa. Located on one of Iowa's outstanding blue-water lakes, the city's permanent population of 4,000 increased each summer to about 10,000. This taxed the water plant's capacity until it was operating on a direct pumping basis. Unpleasant, heavy tastes and odors of algae origin were noted during the summer. Then, occasional high winds would raise the normal turbidity of the lake from 25 ppm to 500 ppm or more.

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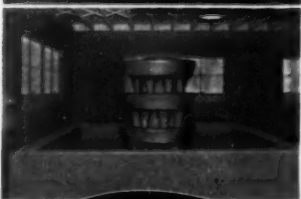
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(Continued from page 72)

able service to consumer. Apart from purity, preoccupation with other duties and lack of technical knowledge often lead to haphazard development and inefficient operation. Many difficulties now facing rural supplies could be overcome by regrouping them in larger units. Formation of joint water boards more appropriate in areas where ratio of rural to urban population sufficiently high to make rural share in control of undertaking desirable. Rural authorities beginning to realize that very heavy price will have to be paid for continued independence. Reorganization on lines suggested would considerably reduce number of undertakings supplying rural areas. Idea not new; envisaged in White Paper "A National Water Policy," issued by coalition govt. in '44. In design for rural area, particularly difficult to est. consumption 10-20 yr. in

future. Danger that trunk and distr. mains will either be wastefully large or too small. Avg. figures furnished in following table:

*Unit Water Requirements*A. Avg. Consumption—*gpcd.* (Imp.)*Domestic*

Rural, unsewered	10-12
Rural, sewered	20-25

Agricultural

Dairy cattle (in milk)	30
Store cattle	10
Avg. cattle	15
Horses, at work	10
Horses, at pasture	6
Pigs	3
Sheep	1½
Goats	1
Poultry	$\frac{1}{20}$

B. Avg. Consumption—*gpd.* (Imp.)/acre*Agricultural*

1 cow/10 acres	1½
Poorly stocked land	
1 cow/ 5 acres	3
1 cow/ 3 acres	5
Ordinary pasture	
1 cow/2½ acres	6
Rich pasture	

Horticultural

Glass houses	2,500
Cold frames	750
Overhead irrig.	1,100

C. Max. Demand Ratio

(Ratio of max. hourly to avg. hourly demand)

Domestic 2½:1*Agricultural* (dairy) up to 4:1*Horticultural*

Glass houses	up to 6:1
Cold frames	up to 6:1
Overhead irrig.	up to 6:1

Because trunk and distr. mains normally represent at least 75% of total cost, it is on these that best oppor-

(Continued on page 76)



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?

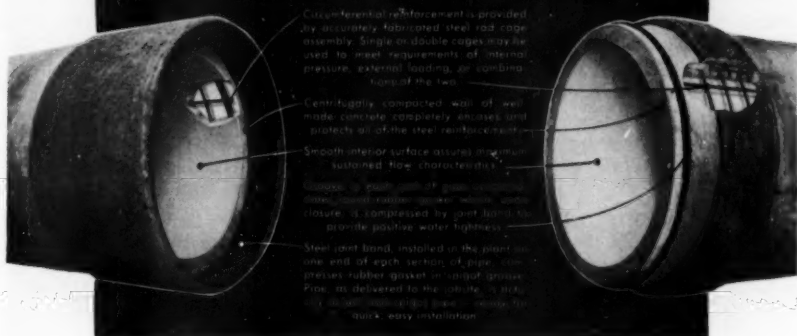
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the cost of delivered water?**

Centrifugally spun, reinforced concrete pressure pipe with double rubber gasket joints combines strength of steel with permanence of concrete.



Circumferential reinforcement is provided by accurately fabricated steel rod cage assembly. Single or double cages may be used to meet requirements of internal pressure, external loading, or combined loading of the two.

Centrifugally compacted wall of well-made concrete completely encases and protects all of the steel reinforcement.

Smooth interior surface assures maximum sustained flow characteristics.

Gaskets, a pair with each pipe end, are made of high quality rubber. When assembled, they compress to form a tight seal, insuring positive water tightness.

Steel cast bands, installed on the pipe at one end of each section of pipe, compress rubber gasket to tight joints. Pipe, as delivered to the job site, is ready for immediate installation. No special equipment or tools are required.

In recent years, development by this company of the Double Rubber Gasket Joint for centrifugally spun pipe has greatly increased its versatility and adaptability. It is proving outstandingly successful in a wide variety of installations throughout the West. Here are typical examples:

Coachella Valley County Water District, Coachella, Calif. (U.S. Bur. of Reclamation Project), Units 5, 6 and 7—270,000', 12" thru 72"; operating heads up to 75'.

Olympia, Wash. (McAllister Springs Water Supply Line) 35,000', 36"; operating head, 150' max.

San Diego County Water Authority (San Diego Aqueduct-Sweetwater Extension) 23,500', 18"-24"; operating heads up to 130'.

Available in diameters from 12" through 84", and for moderate operating heads (generally up to 125'), this pipe is another example of American's ingenuity and skill in the development of better products for water supply lines. Further information is available upon request.

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(Continued from page 74)

tunity arises of effecting economies by planned development and careful design. Min. size of distr. mains has been subject of much controversy. Common size for rural mains is 2"; such mains of little value for firefighting. If development of rural supplies to keep pace with requirements, greatest single need is money; if money and materials not made available serious situation will arise. Alternative—of complete nationalization—would involve disappearance of urban water companies and local authority undertakings. It would also curtail responsibilities of existing joint water boards.—*H. E. Babbitt.*

Statistical Control in the Water Service. JOHN A. DAVENPORT. Wtr. & Wtr. Eng. (Br.), 54:60 (Aug. '50). Application of this technique will show

which local govt. services are good, and to what extent others err, on side of redundancy or extravagance on one hand, or of deficiency on other. When no standard or pattern available, avg. of any group can be used as tent. standard, until agreed standard has been evolved. Statistical control will benefit local govt. because: [1] It will provide tent. standard (group mean) for group performance; this to lead to agreed standard, based on wide practical experience. [2] It offers means of finding yardstick with which to measure service performance absolutely, as against present relative measure. Statistical control methods have been applied to records of 92 communities with pop. from 3,500 to 1,002,000, in following groups: 42 below 50,000; 24 of 50,000–100,000; 18 of 100,000–251,000; 5 of 251,000–

(Continued on page 78)

LIMITORQUE...for SAFE,



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DEPENDABLE operation of valves

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SIMPLEX
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(Continued from page 76)

501,000; 1 in 501,000-720,000 group; and 2 of more than 750,000. "Statistical control" is generalization which separates group from nongroup members, and then divides former into two subgroups, within inner and outer limits—all this without scale measure of relative goodness and badness. To measure service against standard and arrange changes to bring service nearer standard needs yardstick. Basis is scale magnitude between positive and negative inner limits and this is taken to be 100% on new scale. From this start whole scale is marked off in bands, each 40% wide. Starting point is middle band, extending 20% on either side of mean and then go on with markings 60%, 100%, 140%, etc. Middle band is called Standard, and bands on either side become resp. 1st, 2nd, 3rd grade etc. To summarize possible two-directional effect: proposed scale gives rational means of applying social principle expressed in words: "To each according to his needs, and fair shares for all."—*H. E. Babbitt.*

A Review of Reservoir Yields. C. F. J. LISLE. Wtr. & Wtr. Eng. (Br.), 54:63 (Aug. '50). By example, shown that usual calcn. from formulas of estd. yield of catchment area can result in overassessment of yield and thus of compensation water. Catchment reviewed has following characteristics:

drainage area of 7,488 acres, avg. rainfall of 35 in. Relation between rainfall and runoff important in assessing reliable yield of drainage area. Where storage is provided in reservoir yield is governed by runoff over prolonged period. Points plotted on diagram show relation between rainfall and runoff. If runoff equalled rainfall, points would lie along hypothetical line of no loss. Observed that points lie generally on band parallel to this zero loss base. Width of rainfall runoff band, or range of losses, shows limits that may be experienced in period covering March to Oct. Absolute min. runoff (of 0.73") would occur when rainfall is min. and loss is max. Loss values for each period arranged in order of magnitude show 50% of losses greater than 11.3", 13.2", and 13.1" in periods of 8, 10 and 12 months, resp. If catchment area were fully controlled, in accordance with Hawkesley formula, storage capac. would be 1,352 mil.gal. Completely reliable yields would then be, for 8 mo., 6.02; for 10 mo., 4.92; and for 12 mo., 4.22 mgd. Compensation flow would probably, therefore, be fixed by statute at 2.2 mgd., allowing yield of 4.3 mgd. for consumption.—*H. E. Babbitt.*

(Continued on page 80)

Survival and Retirement Experience With Water Works Facilities

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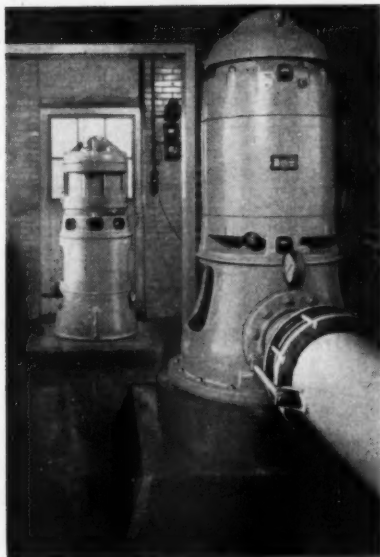


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LAYNE
WELL WATER SYSTEMS
VERTICAL *Turbine* PUMPS

(Continued from page 78)

Deterioration of Cast Iron and Spun Iron Pipes. Ministry of Health Departmental Com. Rept. Wtr. & Wtr. Eng. (Br.), 54:68 (Aug. '50). Recently evidence has accumulated of rapid external corr. of c-i. and spun [centrifugally cast] iron pipe used for water supply, especially those in clay soils containing sulfates. Brief history of use of cast-iron pipe, details of mfg. methods given, together with constituents of metals; casting processes; coating processes; and usual methods of storage, loading and transp. Expln. of processes of corr. deals with subject as chem. or biological reaction, then passes to electrochem. process. Methods for preventing or diminishing corr. dealt with at length. Conclusions reached: [A] *Extent of Problem:* (1) existing standards of

mfg. and of coating protection should ensure generally reasonable life, (2) rapid deterioration of vertically cast and centrifugally cast iron pipe mainly confined to rural areas and to pipes 9" in diam. and under, (3) about $\frac{1}{4}$ of areas in which small diam. rural water mains have been and will be laid consists of formations where rapid deterioration may take place, (4) actual and potential loss in money, labor and materials associated with risks and interruptions to service, provide ample justification for further research. [B] *Corrosion Factors:* (1) corrosion is natural process which can be greatly accelerated under adverse conditions of environment, (2) causes of corr. are electrochem.; underground corr. often associated with microbiological activity; (3) environment particularly

(Continued on page 82)



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(Continued from page 80)

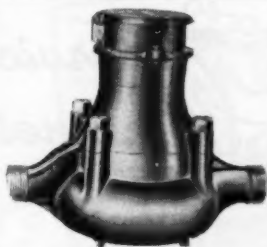
conductive to pipe failures is sulfate-bearing clay, with high moisture and low D.O. content, (4) contraction and expansion of clays cause fracture, esp. if pipe joints not flexible, (5) sulfate-reducing bacteria, found in nearly all soils, multiply under anaerobic conditions associated with these clays within pH range of 5.5-9, (6) leaky joints, undetected pipe breaks and inadequate trench drainage increase natural water content in environment and accelerate corr., (7) deterioration will be accelerated in environment of high elec. conductivity; differences of potential due to variations in environment of pipe may cause rapid, local corr., (8) stray elec. currents passing through pipe to ground cause corrosion at point of departure: practice of grounding electric apparatus to water pipes needs restriction and control, (9) acidity from use of chem. or unsuitable backfilling for trenches may cause rapid corr., but this is infrequent. [C] *Factors of General Character*: (1) there is no evidence that qual. of metal has bearing on rapid deterioration, provided it lies within limits of good commercial practice, (2) evidence that life of pipe depends on method of mfg. is inconclusive, (3) thickness of wall has direct bearing on life of pipe—thicker wall, longer life, (4) protective coatings must be continuous; this is difficult to insure in practice, (5) if good practice in pipelaying is followed, life of main can be extended materially, (6) an early survey should be made of route of main to assess risks of corr., (7) users should keep records of all pipe corr. [D] *Special Protective Measures*: special measures for protection of pipes against corrosion are discussed, and some indication given of their cost. In less corrosive formations, representing further $\frac{1}{4}$ area of England, justifiable to apply special protection to pipes only when there is direct evidence of high corr. condi-

tions. Recommendations of committee are: (1) In noncorrosive formations, departure from present good practice, (2) in formations known to be corrosive, normal coating protection for pipes is inadequate; special precautions should be taken, (3) in highly corrosive areas, appreciable expenditures on protective and other remedial measures are justified; upper limit of such expenditure should not generally exceed $\frac{1}{3}$ of total cost of main constructed with standard materials and normal coating, (4) remedial measures should be chosen from following: (a) use of greater wall thickness, (b) use of flexible joints, (c) protective coatings of greater thickness, (d) use of reinforced bitumen coatings, (e) provision of 3" surrounding of good qual. cement concrete, (f) if available at reasonable cost, provision of 12" surrounding of chalk or granular material, generally in conjunction with other appropriate protective measure, (g) cathodic protection. Usually combination of methods will be desirable. (5) users of vertically-cast and centrifugally-cast iron pipes should report rapid pipe corr., (6) research should be contd., esp. on improvements in protective coatings, effectiveness of various forms of protective measures and relative vulnerability to corr. of pipes mfd. by 3 main processes now employed.—*H. E. Babbitt.*

OTHER ARTICLES NOTED

Ground Water Resources of Jefferson County, Arkansas. HOWARD KLEIN, R. C. BAKER & G. A. BILLINGSLEY. Univ. Arkansas Inst. Sci. Tech. Research Ser. No. 19 ('50).

Chemical Composition of Texas Surface Waters, 1949. ANON. Texas Board Wtr. Engrs. ('49).



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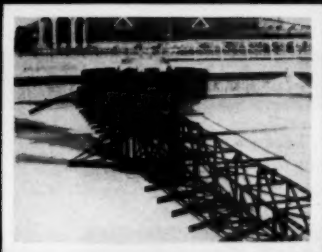


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Service Lines

"Hot Water Circulation" is the title of a fact sheet offered by Water Service Labs., Inc., 423 W. 126th St., New York 27. It discusses piping arrangements in large buildings for making hot water available on tap, without running an initial quantity to waste, and presents maintenance hints for improving circulation and overcoming defects in the system.

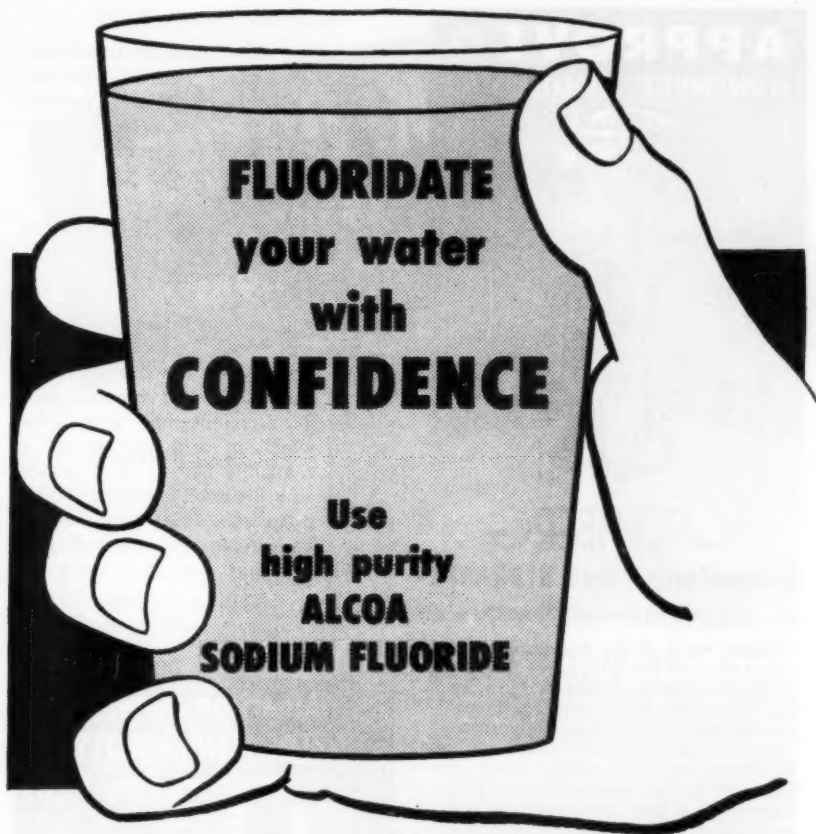
"Chemical Feed Systems," a paper by R. P. Lowe, president of Proprietary Engineers, Inc., presented at the Engineers Society of Western Pennsylvania conference last October, is available in reprint form. The 12-page booklet discusses dry and solution feed systems of various types. Copies may be obtained from the company at Box 1442, Providence 1, R.I.

How prestressed concrete pipe, steel-cylinder type, functions when carrying high heads is explained in a folder being distributed by Price Brothers Co., 1932 E. Monument Ave., Dayton, Ohio.

Remote indicating, recording and control are the subjects of a bulletin, DM029, being offered by Bristol Co., Waterbury 20, Conn. The Metameter line of telemetering instruments is described and typical installations offered as illustration.

Cathodic protection testing equipment available from J. L. Collins, Box 944, Angleton, Tex., is the subject of a catalog folder. The instruments described include a soil bridge, soil resistivity and pipe rod and "Galvometer."

(Continued on page 86)



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(Continued from page 84)

Reducing valve data are contained in a 6-page bulletin entitled "Golden-Anderson 'Cushioned' Water Pressure Reducing Valve." The bulletin, designated W-3, may be obtained from Golden-Anderson Valve Specialty Co., 2091 Keenan Bldg., Pittsburgh 22, Pa. The contents includes a list of parts, dimensions and facts on installation, adjustment and servicing.

A water-level alarm system can be actuated by the Autocon Hi-Level Safety Switch. A rise of only half an inch of water in the bell chamber compresses the air sufficiently to trip the switch, which in turn can set off a visual or audible alarm. The device does not use floats or electrodes. Explanatory bulletin 7500 may be obtained from Automatic Control Co., St. Paul 4, Minn.

(Continued on page 88)

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(Continued from page 86)

Technical cements and industrial compounds are featured in a 62-page catalog, the Sauereisen Engineers' Production Manual, available from Sauereisen Cements Co., Pittsburgh 15, Pa. Jointing and cementing products for a wide variety of industrial applications are described and illustrated.

The high-capacity, visible-flow, Volumetric Chlorinizer, model HCVS, is described in a new bulletin, No. 840-G27, issued by Builders-Providence, Inc., 345 Harris Ave., Providence 9, R.I. Photographs, a cut-away view and a flow diagram help explain the operation of the apparatus.

Bronze and iron body valves of Stockham Valves and Fittings, Box 2592, Birmingham 2, Ala., are cataloged in a 112-page volume available to specifications writers and purchasers. Full data is presented for each valve whenever referred to, and the volume is indexed. A section on essential engineering data is included.

Air compressor motor drives for large industrial applications are described and typical applications discussed in the latest issue of the E-M Synchronizer. A technical section discusses synchronizing power. Copies may be obtained from Electric Machinery Mfg. Co., Minneapolis 13, Minn.

An "Installation Manual" for drainage pipe and structures has been published by Armco Drainage & Metal Products, Inc., Middletown, Ohio. Intended for construction engineers, superintendents and foremen, the 46-page booklet is a handy pocket size to facilitate field use. The handling, assembly and installation of corrugated, paved and multiplate pipe are discussed recommendations for the proper back-filling under various conditions of loading are given.

W & T RESIDUAL RECORDER

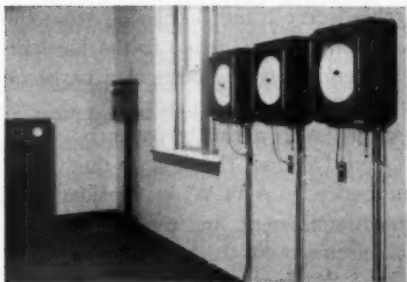
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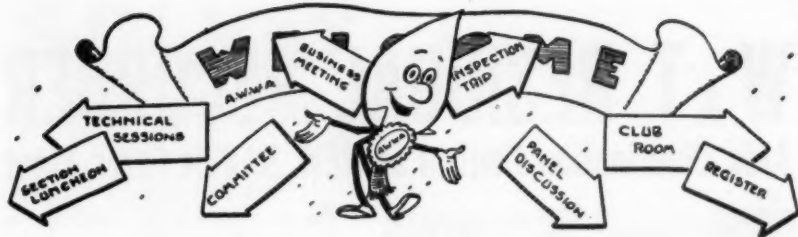
New Haven's experience, however, gives only one example of the ability of the Recorder. This same instrument is successfully at work in other cities of all sizes. Bellevue, Pennsylvania; Bellingham, Washington; Cleveland, Ohio; Kansas City, Missouri; and Atlanta, Georgia—to name only a few—are all now enjoying the benefits of residual recording.

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Section Meeting Reports

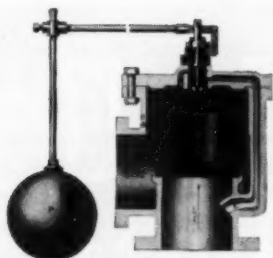
North Carolina Section: The joint meeting of the North Carolina Section and the North Carolina Sewage Works Assn. was held November 13-15, 1950, at the Washington-Duke Hotel, Durham, with 222 persons registered.

The technical session began Monday morning with Chairman E. R. Tull presiding. The invocation was given by Rev. R. E. Brown and the group was cordially welcomed by city officials. D. M. Williams, superintendent of the Durham Water and Sewer Dept., discussed the water plant's recently completed expansion program. An excellent discussion on "The Present Crisis in Municipal Finance" was presented by George Franklin, General Counsel, N.C. League of Municipalities, Raleigh.

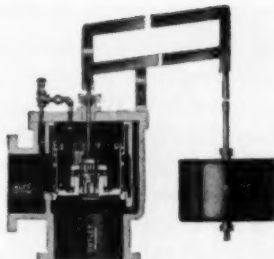
The afternoon session consisted of a water works discussion panel led by W. E. Long, superintendent of the water plant at Fayetteville, and begun by Joe L. Greenlee, assistant superintendent of the Water Dept., Charlotte, who surveyed "Regulations Governing Water Services." John Andrews, supervisor of water purification and plant operation at Raleigh, discussed "Water Plant Records"; George S. Moore, superintendent, Dept. of Utilities, Albemarle, discussed "Use of Radio by Water Departments" (see this issue, p. 227); and E. M. Johnson, director, Dept. of Public Utilities, Raleigh, spoke on "Water Surveys and Unaccounted-for Water." These presentations aroused considerable interest and discussion from the floor. Later in the afternoon an inspection trip was made to the Durham Water Plant and in the evening those attending were guests at a barbecue given by the city at the Durham Shrine Club.

The Tuesday morning session opened with a timely paper by E. Z. Jones, director of the State Council of Civil Defense, Raleigh, on the "Need for Civil Defense in the Present Emergency." A.W.W.A. President W. Victor Weir discussed the replacement of equipment, and the remainder of the morning was utilized by papers on "Discussion of Current Developments in the Stream Sanitation Programs" by J. M. Jarrett, director of the San. Eng. Div., State Board of Health, Raleigh; and "Public Relations" by M. T. Dunlap, personnel director for the Carolina Power and Light Co., Raleigh.

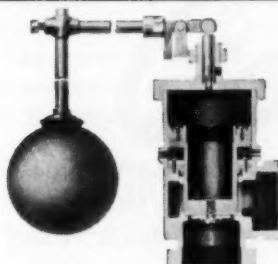
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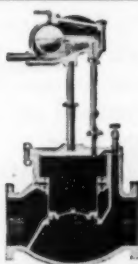
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(Continued from page 90)

The Honorary Luncheon for national officers and guests, held in the main ballroom, was presided over by Chairman E. R. Tull. Addresses were given by A.W.W.A. President W. Victor Weir and F.S.W.A. President Ralph E. Fuhrman. The luncheon was followed by the Annual Business Meeting at which new officers for the ensuing year were elected, reports of committees were received and other business of the two Associations was handled. Perhaps the most important single item of business considered was the consideration of an amendment to the Constitution and By-Laws of the North Carolina Sewage Works Association to permit changing the Association's name to the "North Carolina Sewage and Industrial Waste Association." The purpose of the proposed change in name was to give due recognition to the industrial waste interests and to encourage a wider participation in Association affairs by industry. The proposition was favorably received and the Association members voted unanimously in favor of changing the name.

A Sewage Works Discussion Panel, led by Emil T. Chanlett of the School of Public Health, University of North Carolina, featured short papers and discussions—"Regulating Use of Sanitary Sewers" by R. S. Phillips,

(Continued on page 94)

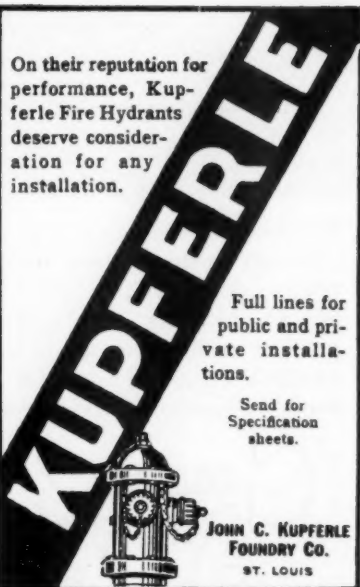


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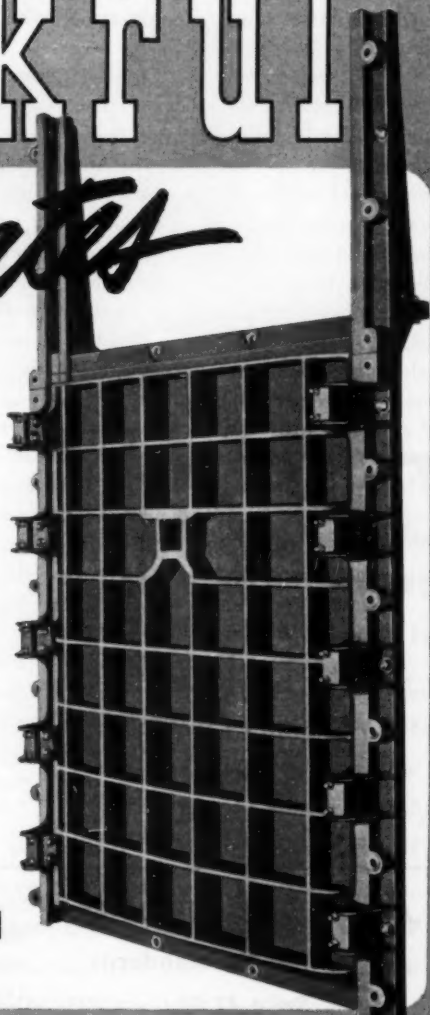
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MORSE
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BROS. MACHINERY CO.
DENVER, COLORADO

Write for Catalog 49

(Continued from page 92)

Charlotte Water and Sewer Dept.; "Sewer Service Connection Policies" by Stanford E. Harris, Supt., Winston-Salem Water and Sewer Dept.; "Laboratory Control of Sewage Treatment" by Wade G. Brown, Durham Water and Sewer Dept.; and "Need for Qualified Plant Operators" by F. R. Blaisdell, district sanitary engineer, North Carolina State Board of Health, Asheville.

At the annual banquet Tuesday night, with Chairman E. R. Tull presiding, the Maffitt Membership Cup was awarded to Harry E. Siebert, Charlotte, for obtaining the greatest number of new members for the section during the year. Following the announcement that R. S. Phillips, superintendent of plants at Charlotte, has been selected to receive the Fuller Award, a new and unique appointment was made. Stanford E. Harris, superintendent of the Winston-Salem Water and Sewer Dept., was solemnly designated *Magister Piscatorum cum Laude* and Curator of the Aquarium. The appointment was made in recognition of a recent and, no doubt, inaccurate newspaper report to the effect that, upon the opening of a fire hydrant in the city system, a live and quite active catfish of considerable proportions emerged and showed much disgust by flopping from place to place in the street in full view of the workmen and many spectators who quickly assembled. The city officials still contend it was impossible; nevertheless the hapless superintendent received the appointment, which afforded much entertainment to all. The principal address was delivered by Paul Gross, vice-president of Duke University, who discussed the development of atomic energy and its use for civilian needs.

The program Wednesday morning was devoted to sewage and industrial waste subjects.

As has been customary during the past several years, clubroom entertainment was provided by the manufacturers. This function proved quite popular and was capably handled by the clubroom committee.

E. C. HUBBARD
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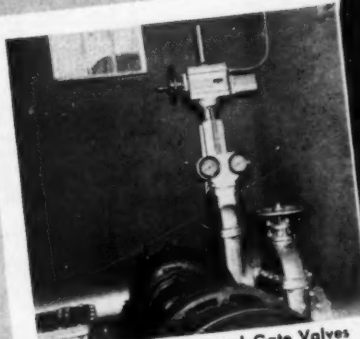
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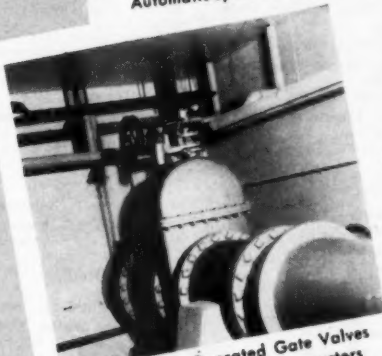
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Mains:

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(See Prof. Services, pp. 25-29)

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(See Prof. Services, pp. 25-29)

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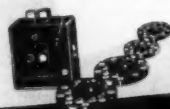
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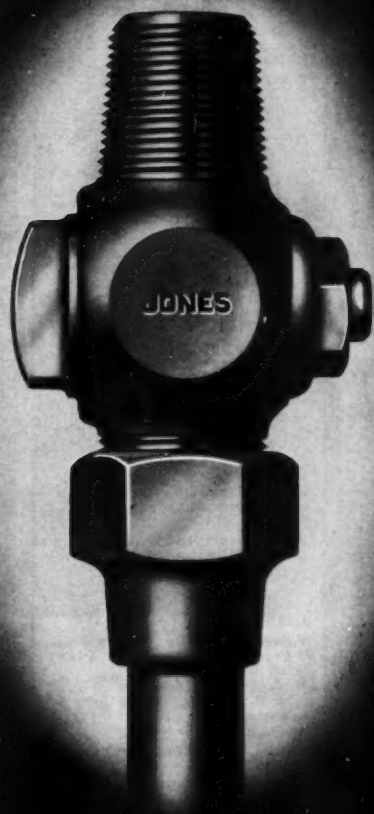
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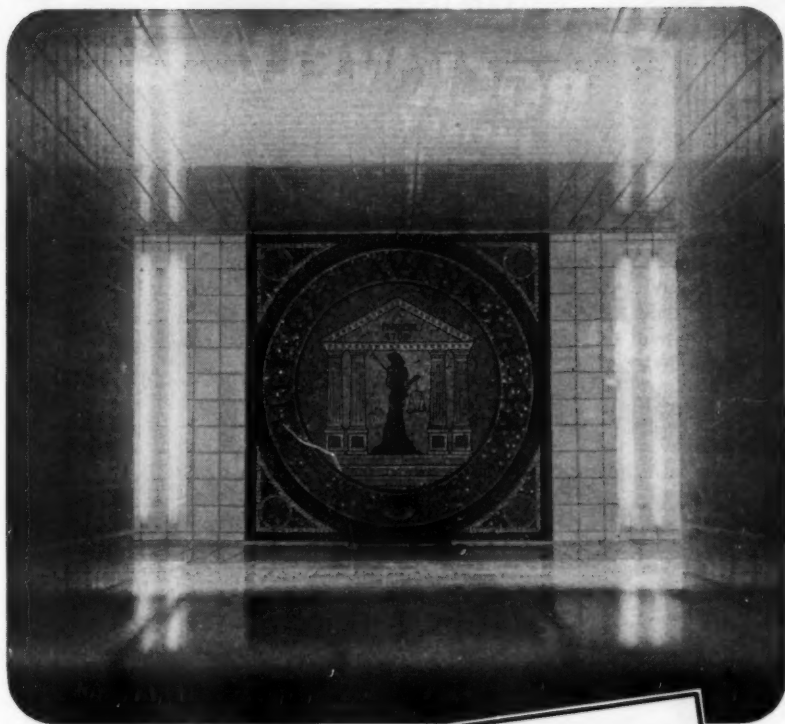
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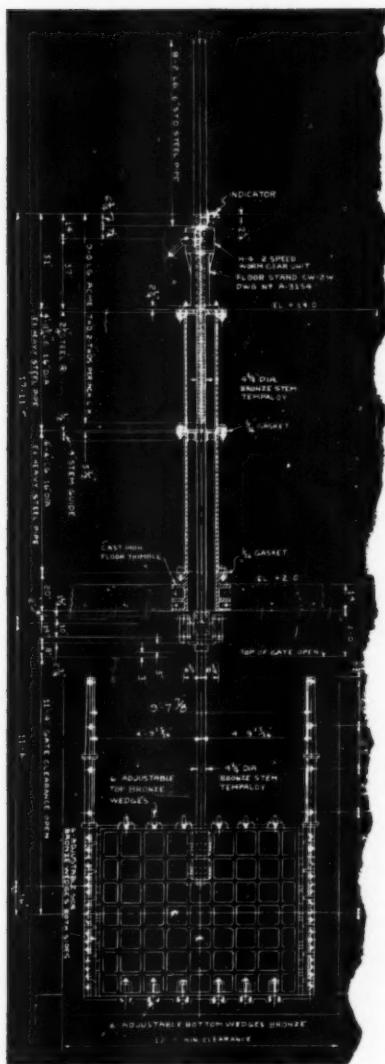
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Size 3 in. and 4 in.
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Sluice Gate in EVERDUR

Designed and built by the Coldwell-Wilcox Division of Krajewski-Pesant Manufacturing Corporation, this inlet and control gate shows an economical use of special metals to give long life.

EVERDUR® (copper-silicon alloy) facing strips, bolting and engaging surfaces were chosen as the best metal known to resist corrosion by tidal waters, partly salt and contaminated by effluents from industrial plants, sewage and the like.

The high-strength back pressure brackets are made of ANACONDA Manganese-Bronze, the same metal being used to couple the stem sections. The 4 1/4 in. diameter stem itself is of TEMPALLOY®, an Anaconda aluminum bronze having unusually high strength properties.

Use of these materials assures the freedom from rust and scaling essential to the long-lasting adequate strength and easy operation so much desired.

Anaconda engineers are available to cooperate with you to obtain similarly dependable and economical equipment. Write to: The American Brass Company Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 51135A

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Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

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